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THE COXEY CRUSADE AND ITS MEANING.

A MENACE TO REPUBLICAN INSTITUTIONS.

By William Nelson Black.

"OH! Coxey is a lunatic," exclaims the industrial operator engaged contentedly in the prosecution of his work; "you do not propose to discuss the peregrinations of this cross-country tramp through the dignified pages of an engineering magazine?"

But Coxey is the representative—a somewhat exaggerated representative it may be—of a class determined upon the humiliation, if not the spoliation, of every industrial worker who has become an employer of labor; and we cannot afford to ignore his peregrinations merely because he has chosen to put on an antic disposition. He differs but little, after all, from the men who have elevated his flag in the senate of the United States, and the whole party of Populists, State Socialists, and paternalists of both the old political parties could very consistently be training at his heels. He is a clear-cut representative of an old foe of popular liberties which is masquerading under new names, and he is hardly the less dangerous because he represents a minority, comparatively insignificant, of the total population of the country. Under our scheme of universal suffrage, or possibly under any scheme of self or representative government that could be devised, the factions holding the balance of power, composed generally of the most illogical and narrowly-trained members of the community, are able to impress themselves on the public policy to a degree far beyond the warrant of their numerical strength or merits. Have we not seen the Democratic party almost rent in twain in an effort at surrendering its identity and occupying ground directly opposed to its tenets for the purpose of catching the Coxey contingent, or the faction of which Coxey is the most distinguished representative? Then it would be exceedingly un-

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wise to say that any political manifestation should be ignored because it is seemingly insignificant.

It may be said, however, that these are subjects for discussion in political journals or among political philosophers, and that they do not directly concern the hard-headed practical men engaged in industrial and other economic pursuits, to whom these pages are devoted. But this would be wrong again. Have we not recently seen the Coxey contingent at work even in the metropolitan city of New York? There is an industrial organization in New York engaged in furnishing rapid transit to the city. It furnishes better rapid transit than any other corresponding organization in the world, and it is better prepared to furnish improved rapid transit, if it could only be permitted, than any other agency. Yet we see an attempt made to knock it out with a municipal bludgeon in the shape of a proposal that the city shall build a system of underground railways. Even the New York Chamber of Commerce, a body of merchants who have lent themselves to the scheme, could very properly be organized into a militant company for the Coxey brigade, and, under the captaincy of the respected citizen whose fitness for command will be universally conceded, sent out to battle in behalf of the plans which Coxey is endeavoring to promote. It will not do to say, therefore, that Coxey is a personage of no importance to practical men. They are the only men whom he does vitally concern; and he is all the more dangerous to their interests because, partly on account of absorption in their pursuits and partly because of their lack of comprehension of the danger, they permit themselves to remain apathetic.

What is the significance of this Coxey crusade? As to Coxey personally, there will be little difficulty in sketching his most prominent features. He is simply a man with an unballasted head, an adventurer who has made war on the United States government and constitution, unwittingly. The mouth of this American Don Quixote has been as full of peaceful professions as the mouth of a German kaiser or Russian czar; but his organization, it will be observed, is military, and it is fair to presume that every recruit in his ranks able to buy, beg, or borrow a weapon is armed. But it is not probable that there is coherency enough in his head to enable him to comprehend his attitude. He is simply a social freak, and is hardly to be called a promoter of civil war. And in attempting to analyze the Coxey crusade we find ourselves carried at once into the commonplaces of history. Coxey planned his invasion of Washington to compel the federal government to build some new and better roads. We see, therefore, that the scheme is comprehensive. The New York Chamber of Commerce has recently invaded Albany to compel the state of New York, through its municipal

agent seated on Manhattan island, to engage in a precisely corresponding enterprise. But the suggestion raises historical reminiscences. The Roman empire was a great road-builder in its day; and now that the fact must be recalled, we are reminded that the United States, in the earlier days of their career, built a few roads, and they might have continued at the work to this day had it not been discovered that it was hardly a constitutional field for the exercise of functions created for the protection of life and property. We are a commonplace people in the United States, and do not take kindly to the magnificent and helpful conceptions of governmental paternalism. Yet we have managed to build, during the last fifty years, about 200,000 miles of incomparably better roads than the Roman empire ever conceived, and will build several million more miles of a corresponding kind, and by corresponding processes, during the fifty years to come. Road-building is the great engineering and industrial specialty in the United States; but the kind of roads that we want—railroads—never enters into the conceptions of the tramp, and the truly republican expedients for their construction seem to be something entirely beyond his comprehension.

The truth about Coxey is that he is a representative of much more than he imagines, but a representative who does not comprehend his own constituents or understand the cause that he is trying to serve. All over the world, where men are sufficiently enlightened to know their own capabilities and rights, imperialism, the other name for paternalism, is at its last gasp. But it is trying as it never tried before to convince men that it may be useful if they will only lend it enough of their substance to give it the ability to work in their behalf. Forgetful of the fact that all manly men prefer working in their own behalf, this seems to be the prevailing inspiration in the new propaganda of imperialism; and hence, in chief part, though military considerations and depleted exchequers are not without powerful influence, those government railways and telegraphic lines that cross and recross the leading continental countries of Europe. Hence, also, the craze for a corresponding absorption by government of industrial functions in England, for the Englishman is generally a very sensible being until you touch upon the permanency of the monarchy, and then he becomes as erratic as any Don Quixote. All his efforts looking to enlargement of municipal powers by the invasion of industrial fields, and all his longing for government possession of the railways, are really inspired by dread of the revolutionary elements that alarm the higher and middle classes, and keep the ground continually trembling underneath the throne. True this is not the ostensible plea for the efforts at strengthening the resources of government; but it is the only logical plea that could be made, and we need not trouble ourselves about any-

thing ostensible if it is upheld in defiance of logic. The whole brood of State Socialists in Europe, of whom Coxey may be called an American representative, were fashioned in an imperialistic mold; and, however viciously they may kick against the service to which they are assigned, they may be sure that they will be made component parts of a regal edifice.

Men must not for a moment imagine that there is anything new in what is known as Populism in this country and State Socialism in Europe. Sixty millions of peasantry in Russia, with hardly intelligence enough to keep them from starvation, are living, as possibly their ancestors for a thousand years have lived, on lands held by substantially the same tenure advocated by Henry George in his "Progress and Poverty"; and, had Edward Bellamy only looked backward in his dream as far as the declining days of the Roman empire, he might have paused by the way and seen Mahomet II knocking down the gates of Constantinople in order that he might extinguish a nation that had found so many Bellamys among its statesmen that it had become too much enervated and too worthless to live. State Socialism is old. It is even prehistoric in its antiquity and dates certainly from the cave-dwellers. Civilization is its antithesis.

In treating of Coxey and his hosts, however, it will not be necessary to go very deeply into historical research. A mere glance at the past will serve to show that Populism can neither create nor preserve a great nation, and the best field for illustration will be found among the people who have built up from the wilderness within a hundred years the most powerful nation on earth. Even the enemies of the United States cannot deny that they have done wonders. But they will ascribe the rapidity of our advance to wrong causes. They will first credit it to our expansive territory. But other nations that remain comparatively insignificant have as much territory as the American Union. England herself holds three or four times as much, and Russia, hardly yet civilized beyond a few millions of her hundred million inhabitants, has vastly more. It cannot then be our expansive territory that has given us the lead. But they will ascribe it, also, to immigration. We have drawn immigrants, however, only because we offered employment, and, everything considered, our advance was quite as rapid during the first decade of our history, before any considerable immigration began, as it has been during the last decade. Between the close of the revolutionary war and the beginning of the second war with England, a period of about twenty-five years, our population rose from less than three millions to over nine millions. We have the right to claim, therefore, that our rapid advance to the leading material position among the nations of the world has been due,

and exclusively due, to our political and social policy. Then what has been this policy? By understanding it and pursuing it we may best secure the future.

Henry George, Edward Bellamy, and even Coxey himself must be forgotten here, and something said for Thomas Jefferson. The beginning of the American revolution marked a new era in the political history of the world. Down to the date of the Declaration of Independence the true functions of government had never been clearly formulated. In a chaotic or nebulous condition the principles enunciated in that declaration of rights permeated English society, and modified the British constitution; but the limitations of government and its true purposes were in no country clearly understood. Political authority in all countries, wielded by sovereigns or parliaments, or by sovereigns and parliaments acting together, might have been defined in terms not unlike the terms selected by Madame De Stael for describing the government of Russia. It was an absolute despotism tempered by the fear of revolution. There were no reserved rights for the unofficial classes. There was absolutely no limit to the powers exercised by the heads of the state except the boundaries erected by expediency; and to be king implied the exercise of any authority that did not endanger the crown. There would have been halcyon days for Coxey when George the Third was king. If not hanged for his impudence, he could have presented his petition with boots on to the two houses of parliament or to the king himself, and if it was not granted it would not have been because of constitutional obstructions.

But while this was the conception of political power in Europe, the conditions for change were preparing in America. Along the borders of a wilderness, far removed from courts and camps, a hardy race grew up to some numerical strength, and these men, unfamiliar with the burly figure of a tipstaff at every turn, soon discovered that "that government is best which governs least," and yet serves the purposes of government. In the wilderness they learned to plow when the field was fallow, to put in the sickle when the harvest was ripe, and to protect themselves betime with their own right arms when forced to submit to savage invasion. In short, they learned how much men could do to help themselves when left to their own resources; and hence, finally, a new code of social precepts, a Declaration of Independence, and, in the end, a new constitution to embody permanently in a political organism the principles by which they were controlled. They were principles, too, which will be applicable forever, or until a still higher evolution of the race permits a yet longer stride in the direction of the complete enfranchisement of the individual. Men in America have been taught that it is not only their privilege, but their duty, to act in

their own behalf, and that they themselves, individually, and not the governing classes, whether elective or hereditary, form the constituents of society. This is our code, and it has been due to the general acceptance of such tenets that the United States have advanced so rapidly, while the nations of Europe, handicapped by their lumbering political machinery, and enfeebled by its weight, though advancing, have moved at a snail's pace, and are compelled to see avalanches of the best elements of their population departing annually for the less obstructed soil of the American union. Consider for a moment what Russia would be to-day if, in place of her state socialistic system of land-tenure and her few thousand miles of government railways, built chiefly for the transportation of soldiers, she had free lands and 200,000 miles of railways built, owned, and operated like the railways of the United States! Emigration would be moving eastward rather than westward, and not only all Russia herself, but the waste places of southern Siberia would be covered by a teeming and energetic population.

It will be necessary, however, to take leave of Thomas Jefferson and his policy and to come back to Coxey. The cohorts of this new order of generalissimo, reinforced, metaphorically at least, by the New York Chamber of Commerce, have been invading the steps of the capitol, and we must try to comprehend the meaning of the assault. Does it mean that any considerable proportion of the American people are prepared to abandon the political ideas that were formulated when the Union was formed, and return to the ideas that obtained under the rule of the Georges? Or does it mean that a considerable number of our people, discouraged by the riotous spirit of the times, have come to the conclusion that our ideas of government need stiffening a little—just enough to enable us to deal more sternly with the disorderly elements—and that they are willing to humor the cranks for their own semi-revolutionary purposes? No, it is not to be conceived that either of these questions can be answered in the affirmative. No country handles the disorderly elements so successfully as the United States, and we must find some other cause for the apparent changes in public opinion. We shall find it, it is to be feared, in ignorance,—a most discouraging reflection after all the expenditures that have been made for the support of our public schools. But it may be possible that our public-school teachers have spent so much time in extolling the heroic character of the revolutionary leaders that they have forgotten to teach what those leaders represented; and, if this be true, it would be best to follow the example of the time when a history of the United States was the only school-reader in use, and when every pupil was forced to read aloud a passage from the national records each

morning before proceeding to his more laborious studies. The history of the United States may not be a very good book for teaching the accomplishments of elocution, but while it was in daily use among the rising generation we were growing continually further and further away from Coxeyism and all that this remarkable leader represents.

But, after all, this is a poor country for both cranks and fools. True, it has seemed for a few years past as if they held some sort of congenital relation to the soil, and that it was highly fertilized to promote their increase. The crop has been certainly redundant, but, while they have played some curious antics with our laws, they have hardly yet made an appreciable impression on our institutions. The country is generally directed in the end by its men of ability and training. But the cranks are giving us a hard time. This much must be conceded; and there is reason to feel a little impatience for a return of the day when men were taught that work was something to be done by themselves individually and not by government, and that it is better to work under a "boss" than under a slave-driver. In short, as Congressman M. D. Harter has very aptly said, what is needed just now is to "publish far and wide that it is not the business of the United States to raise prices, provide work, regulate wages, or in any way to interfere in the private business or personal affairs of the people. If we go on in the mad chase after prosperity, under the leadership of the Coxeys, McKinleys, Stewarts, Peffers, Blands, Hatches, etc., we will find harder times and greater suffering ahead of us. The troubles we are having are the outgrowth of simon-pure paternalism. Our country, with all its magnificent resources, is still here; our people have not lost their skill; and we can be as prosperous and happy as ever, if we demand equal laws and a sound currency from the government, and then work out our own salvation."

AMERICAN ARCHITECTURE THROUGH ENGLISH SPECTACLES.

By Banister F. Fletcher, A. R. I. B. A.

TO a European the study of the progress of architecture in a new country and under conditions which do not obtain in the old world must be exceedingly interesting, and, provided the criticism be undertaken with sufficient open-mindedness and not too much insular prejudice, I take it that the result of the investigation should be of interest to the American architect.

My tour commenced with New York, whence I went to Philadelphia, Baltimore, and Washington, across to Chicago, and back through Canada to Boston and New York. This, done somewhat thoroughly, would, I am given to understand, give one a very good idea of the more important buildings and the general methods of architectural practice. The influence of ancient styles still seems to hold remarkable sway, especially in some of the more important buildings, but, as far as one can see, with the exception of some particular works by a prominent firm of New York architects, the influence of style (as we understand it) seems to be on the wane and there seems to be a general breaking away from precedent. Of course in many cases this is due rather more to ignorance than to any desire to be original for originality's sake.

It is hardly possible to speak of American architecture without reference to the training of the architect himself. Most of the leading architects, with a few brilliant exceptions, appear to have received their preliminary training at the École des Beaux-Arts at Paris, and there is no doubt that (although in England we despise it because it is not English) it is a capital training in the classic manner, and also in style and composition. Oddly enough, the training seems peculiarly suited to the American because he forgets it, for in the great majority of cases he wisely lays aside the strict classic forms and ideas and, always aided by having had a thorough grinding in the principles of his art, he sets forth bent on solving new problems in a new way, and does not seem to be bound down by any of the obsolete rules of the studio.

In respect of new problems, new wants, and new difficulties to be overcome, the American has a great advantage in that he has to solve them in a new way and therefore should not fail to be able to

present new forms, while we over here generally have to design buildings which are to be used for the same purpose as hundreds of others, and yet we are expected to do something strikingly original, which, if done, is usually very bad.

In domestic architecture we may see at once some very original work, treated in a manner which is picturesque and suitable to modern needs. We might divide this heading into monumental work and purely domestic work. In the former class we must of course classify Mr. Richard M. Hunt's important country works. Now Mr. Hunt is French, "quite French," even more so than any of his fellow-architects who have studied at the École, and perhaps in consequence of his more prolonged residence there. I was fortunate in seeing some of his work at Newport, but found nothing very remarkable in his house for Mr. Goelet, the exterior being conceived in the Henri II style, and rather hard in treatment. It is far more satisfactory in the interior, with a fine staircase, somewhat later in style, and executed in Caen stone. The details of this staircase and the hall generally are very carefully worked out, and the workmanship of the stonework generally reflects great credit on the masons employed. The method of bringing over mantelpieces and ceiling paintings from France or Italy is surely the owner's caprice, and is not conducive to the progress of architecture, however good the articles in question may be.

On a more ambitious scale is the château Mr. Hunt is building for Mr. George W. Vanderbilt in North Carolina. From what the architect showed me of the plans and model I should say that this is one of the most extensive architectural conceptions of modern days; he has had the coöperation of Mr. Olmsted, the landscape architect, as to the general disposition of the grounds surrounding the house. The whole scheme seems laid out on a most grandiose scale, regardless of expense, and has given Mr. Hunt an opportunity that can rarely occur to an architect, of giving him the full play of his fancy and experience. The design is based on the old châteaux of Chambord, Chenonceaux, Blois, etc., and the scheme bids fair to be one of the most successful of any age. It will be interesting as a comparison with our Blenheim Palace by Sir John Vanbrugh, the largest and most extravagant of palaces in England, to the character of whose architecture Pope sarcastically referred on the architect's death:

> "Lie heavy on him Earth, for he
> Laid many a heavy load on thee."

Before proceeding to the purely domestic side, we might remark on the lavish expenditure on their houses by rich Americans. Of course we must allow for the higher price of labor in the States, but even then

a man seems to spend £50,000 where over here he would spend half or even less. Mr. George B. Post's work for Mr. Cornelius Vanderbilt, which he kindly showed me over, shows considerable skill in planning and adaptation to modern requirements, although rather too French to suit our insular ideas.

It is with great delight and satisfaction that I approach the country houses by Messrs. Peabody and Stearns at Newport, R. I., and the more so because of the fact that I believe Mr. Peabody did not study in Paris, but in England, in the office of Mr. Alfred Waterhouse, R. A. Here indeed we have food for reflection and here indeed we have architecture in its truest and widest sense. In two of the houses which I visited in company with Mr. Peabody, and which are situated on a rocky prominence overlooking the bay, one really felt as if one were in a new country where new ideas were being given full play without regard to rusty formulæ or pedantic precedent, where designing was done with a love for the work and a sympathy with the objects of the design and of the materials at hand which we, in an old country saturated with "old examples," can hardly hope to attain. The houses, especially one of them, seem to rise so naturally and so gracefully out of the rugged rock foundation as to be part almost of the soil, the lower story being built of a rough bluish granite in thin courses and large open joints (the mortar being kept back from the face for the purposes of effect) which give a texture to the face; gradually as we get higher in the composition the roughness changes to the more polished surface of wood and shingle. The plan, too, with its spacious hall and ample staircase, seems to tell us, but in a fresh manner, that the wants of the modern American are not unlike those of his Elizabethan ancestor. The only point in the house which would not be found in the sixteenth century is the spacious roofed piazza, curving around into the promontory, and from which an extended view of the bay can be obtained.

Another interesting specimen of these architects' work, which, without any affectation whatever, made one think of an old English homestead, was a group of houses, set back from the road, with an open "green" in front, fringed with a low stone wall, in which all the elements of subdued and self-restrained design, so characteristic of our own "old work," are present. Perhaps nothing else during my stay in America gave me so much pleasure as this quiet domestic work of Messrs. Peabody and Stearns.

Of the wooden or frame houses of which so many exist in America there seems not much to say, except that they lose in trying to be too much, being crowded with features, but it must be owned that in several instances, presumably where architects have been employed, they are at least satisfactory. The influence of Richardson, too, is

painfully apparent in old and hackneyed features, for the old low semi-circular entrance has surely had its day. Why is it necessary to use it everywhere, from the humblest cottage to the most pretentious mansion? Truly a master in architecture (as Richardson undoubtedly was) has much to answer for when he seems to have the power of hypnotizing fellow-architects into copying his most ordinary features.

On the less ambitious domestic architecture in towns there is some very good work in the States; in Chicago, for instance, on Michigan avenue there are some houses inspired by Richardson, but at the same time exhibiting a certain freshness of design that is noteworthy. In the suburbs of Brooklyn I was particularly charmed by some houses, designed and elegantly fitted in a style somewhat resembling our own domestic work of the same type and cast in the same groove as the work of the late John D. Sedding, with large flat surfaces, the ornamentation massed at points to form contrast. The ugly stoop of the pattern-book Brooklyn house was, in these houses, made a feature, being treated in a novel way by side entrances, which helped to break the dull monotony of a Brooklyn street.

In civic architecture I enter on a section which has filled me with wonder and amazement. Philadelphia! O Philadelphia! the ancestral city of the antique Britisher, the home of cricket and other British sports: why wast thou built thus rudely to show thy face to a descendant? —thyself being in the rear, the very rearguard of American architecture! One can hardly believe that in any one city in the world there are crowded so many monstrosities in the way of architectural design as in Philadelphia, and yet one has one's reward in visiting the place, for in the work of some of the younger men especially there is good material. I would refer to Mr. F. Miles Day and Mr. Wilson Eyre, both of whose work is fresh and full of true artistic feeling. The Art Club, by the former, is a somewhat pure type of early French Renaissance and stands as an oasis in a desert of bad work, and there are two or three other works by the same architects noticeable for freshness of taste and inventiveness in design. But ye architectural student in search of novel treatment, I pray thee, visit not the University!

From Pennsylvania to Chicago is a far cry, in regard both to distance and to architecture. My first impression of the tall building did not overwhelm me as much as I expected. In the first place, I do not belong to the school of architects (in reality, antiquaries) who dislike tall buildings because they are tall buildings, but rather to the school which, being bound to admit the necessity of the case, would endeavor to so carry out the design as to incorporate true principles of art. Now the Chicagoans have decided that they want tall buildings, that they must have tall buildings; therefore it behooves the Chicago

architect to cope with this new problem of design and construction as architects did in the olden days when architecture was a progressive art and when everybody did his best in that state of architecture in which he was called.

Can you imagine a medieval architect (or master-builder, or chief workman, whichever he styled himself) uttering his laments and casting up his eyes to heaven when his lord told him that he was tired of sleeping in the common hall in the midst of his retainers and that he must have a "solar,"—yes, a private sleeping chamber for himself and wife!—thus starting all the development of domestic plan? What would the modern antiquarian-architect have said? Why this: "I can see no precedent for a private-sleeping chamber; your father had none and it would spoil the symmetry of your old Norman keep if I tack on chambers, with drawing-rooms and offices!" But the architect did no such thing; he had to fulfil conditions as we do and did it, as we should do, taking a delight in his work. And so, as tall buildings are a product of the age, let us glance at how the most successful designs are carried out.

It would appear, in the first instance, as if the cardinal principle to be adopted in designing a building would be to make it appear what it really is, namely, *one* building, or, in other words, to follow up the principle of *unity*. It was one of the greatest principles insisted on by the Greeks, this one of unity,—variety *in* unity, if you will, but you must have unity. Now this is *not* to be obtained by laying one floor on another with strongly-marked horizontal lines, as we note in some of the designs produced for these buildings, but in applying the same *principle* as the Greeks did to their one-story buildings.

The classic column is primarily suggestive of unity in both expression and purpose; with its entablature complete, we can take away none of the parts without spoiling the whole. Apply the same principle to a tall building, and what do we get? Firstly, a base,—the lower one, two, or three stories (according to the height of the whole composition) bound together by strong horizontal lines corresponding to the molding on the base of your classic column; then come the next ten or twelve stories, which should be treated plainly, corresponding to the fluted shaft of our column; next the upper stories, answering to the capital of the column with projecting cornice and binding horizontal lines. In what building do we find these principles carried out? In the Schiller Theater, by Messrs. Adler & Sullivan. This building appeals at once to me as being the best designed tall structure, not only in Chicago, but in the States. The architects, by a clever manipulation of the front, have made the central part what it really is, what every tall building is more or less,—*i. e.*, a tower;

by keeping down the end portions and letting the central part disengage itself above them, it freely expresses itself. The two lower stories of the whole façade are bound together, as they should be, by strong horizontal lines, emphasized in this case by a happily proportioned projecting balcony, which, with the deep shadow it casts, aids the horizontal effect to be aimed at in these lower stories; then follow the ten or twelve stories (I forget how many), corresponding to the shaft of our classic column, the windows recessed, as it were, in the hollows of the flutes and plainly treated. The tops of the piers are connected by arches, without moldings or pseudo-capitals,—in fact, as the arrises between the flutes in our classic column; and the remaining stories are tied well together by horizontal moldings and crowned by the overhanging abacus of our capital or cornice. I take it, in fact, that the Schiller Theater is in the same relation to the new style of tall building as the Parthenon bears to the architecture of Greece.

Among other tall buildings which appeared to me worthy of notice was the Monadnock building, by Messrs. Burnham and Root, in which slight projecting bays are worked into the design; the rounding of the angles in the building is peculiar, but need not be repeated. The great charm of the building is its simplicity, and I would suggest to every one designing a building of this size to "let it alone" and allow it to tell its tale by its boldness of mass and proportion, and not to fritter away the dignity which size can give by an unlimited and totally unnecessary crowding in of small detail. I mention this because there seems a tendency in this direction, especially where terra-cotta, which is so easily cast into molds, has been employed. The Masonic Temple, by Messrs. Burnham and Root, is another building in which the vertical principle is well maintained. In the arrangement or plan it is calculated to "give pause" to any benighted Britisher. Fancy entering a building in London and, after passing through a vestibule and hall fitted with well-designed iron-work and lined with marbles, coming upon an array of fourteen elevators arranged in a semi-circular plan, each under the charge of a guard and with a head-guard over all sending these vertical-train loads of people "on time" express to such or such a floor, or calling at all floors up No. so and so.

The lift (I should say "elevator") fittings generally in the States I found to be excellent, in both design and execution, and our English designers might learn a good many lessons in the way they are fitted up, especially in the iron or copper screens with which they are enclosed. The internal fittings of the Auditorium building struck me as being exceptionally well carried out, more especially in the restaurant, where stamped and burnished copper as a covering to the columns, etc., are carried out in excellent design.

A word or two as to church architecture. I am bound to say I was disappointed with a good deal of what I saw. Richardson's masterpiece in Boston is no doubt fine in its general conception, especially if we remember when it was done, and more, it is adapted to the modern preacher in America, where the sermon takes such an important place in the service. The stained glass, however, which should have been used sparingly, having regard to the size of the windows and the style of the building, has been much over-done, for the interior, even on a bright day, is in semi-darkness.

I was very pleased with the bold, rich effect of Richardson's work at Harvard University. The effect of Richardson's individuality on church work has, I should say, been enormous, although I was perhaps unfortunate in not seeing any specially fine churches ; but I am convinced from what I have seen in the way of drawings and photographs that there is a great future for American ecclesiastical work. As a type which will perhaps be understood, I may mention a Presbyterian church near Cincinnati, by Mr. Martin Aitken, as being Romanesque in feeling and yet imbued with considerable freshness of design. The church of St. Agnes in New York, by Mr. W. A. Potter, contains some elaborate marble and mosaic fittings, reminding one at once of the church of San Clemente at Rome and of the cloisters of St. John Lateran, and quite equal to the latter in execution, reflecting great credit not only on the architect but on the liberal-minded policy of his clients.

I take it that no criticism on modern American architecture can be complete without some mention, however short, of the great national effort in the Chicago exposition, but my remarks must be brief. From the point of view of architecture the show was a grand success, both as a demonstration of the ability of the architects of America to rise to the occasion, and also for the opportunity it gave of calling in the assistance of the allied arts of painting and sculpture. It fell to my lot in 1889 to visit the Paris exhibition to report thereon for the Architectural Association, and so I have had a good opportunity of forming comparisons. Of course the Chicago exposition was different in every respect to what one expected. One looked for some new development shown in either iron or terra-cotta, or both, or perhaps wood alone, being in the center of a country which is the center of the lumber market ; but "extremes meet," and so we find an exposition of architecture on the wilds of the western prairie which is a collection of well-studied Parisian designs. There is something to be said in its favor, perhaps, as an object-lesson to Americans, and the whole scheme was certainly carried out with a thoroughness of purpose and a lavishness of money worthy of all praise. I must mention here a word of unstinted praise to Messrs. Adler and Sullivan for their Transportation

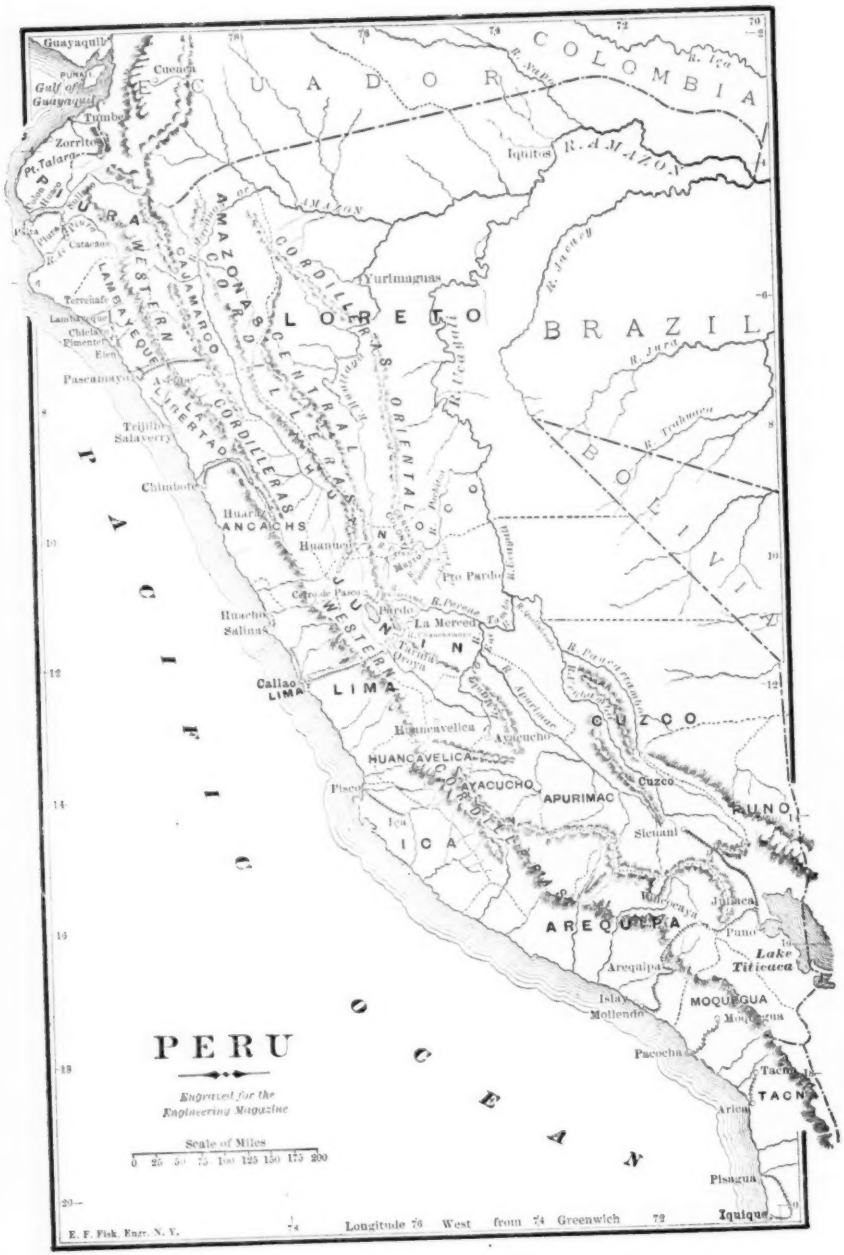
building, a color scheme perhaps too novel and too new for the average American, but coming fresh as the first rose of summer to the jaded European.

Let us hope, however, that the imitative element will not cause the great classic designs of the Chicago fair to be reproduced for town halls, museums, etc., but that American architects, already advancing so rapidly along certain new lines of departure, will value the lessons they teach without copying the forms which they present to his eye; if not, we shall see a great American classic revival which will go far beyond any craze we have had in England and do more to retard the true progress of art in America than if no exposition had been held.

In conclusion, I am certain that there is a great future for American architecture if only the architects will, as much as possible, express themselves in the language of their own times. No advance can be made by the wholesale copying of ancient buildings as has been done in one or two cases, constituting a retrogressive movement and showing a sad want of the appreciation of the true value of art.

The great styles must of course be studied and well studied, not for the forms with which they abound, but deeper still, for the principles which they inculcate, in the same way that one studies the literature of the past, not to be able to talk in a dead language, but the better to be able to do so in a living one. If this is done, and done with the earnest intention which a true artist has of producing works which shall reflect the hopes, needs, and aspirations of the life and character of the age in which he lives, a good result must be assured.

LONDON, March, 1894.


Guayaquil
Gulf of Guayaquil
Cuenca
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Chiclayo
Pimentel
Eten
Pascamayo
Trujillo
Salaverry
Chimbote
Huaraz
ANCACHS
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Cerro de Pasco
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Salinas
Callao
LIMA
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Cuzco
CUZCO
PUNO
Sicuani
Juliaca
Pano
Lake Titicaca
AREQUIPA
Arequipa
Islay
Mollendo
MOQUEGUA
Moquegua
Pacocha
Tacna
TACNA
Ariea
Pisagua
Iquique
Iquitos
Yurimaguas
Pto Pardo
La Merced
Pisco
Ica
ECUADOR
COLOMBIA
BRAZIL
BOLIVIA
LORETO
R. AMAZON
R. Napo
R. Iça
R. Jurua
R. Jutahuaca
R. Jacuruy
R. Pastaza
R. Huallaga
R. Ucayali
R. Perene
R. Apurimac
R. Pampas
R. Paucartambo
AMAZONAS
CAJAMARCO
LAMBAYEQUE
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PERU
Engraved for the Engineering Magazine
Scale of Miles
0 25 50 75 100 125 150 175 200
E. F. Fisk. Engr. N. Y.
Longitude 76 West from 74 Greenwich 72

BUSINESS OPPORTUNITIES IN PERU.

By H. Guillaume, F. R. G. S.,

Consul-General for Peru at Southampton, England.

PERU awaits only the development of great natural resources to give her an important place in the world's commerce. Native enterprise is deeply concerned in the country's progress and a welcome is extended to all, of whatever nationality, who come prepared to extend the work of development. There are fine agricultural and pastoral lands, mines rich in the precious metals and copper and lead, petroleum-fields ranking with those of Pennsylvania and Russia, virgin forests in great variety, and immense sources of india-rubber. But, with an area one-seventh as great as that of Europe, the population does not exceed 3,000,000, more than half of which is composed of Indians, so that great need exists of an increase of population and additional capital to carry out on a commensurate scale the development of the natural riches.

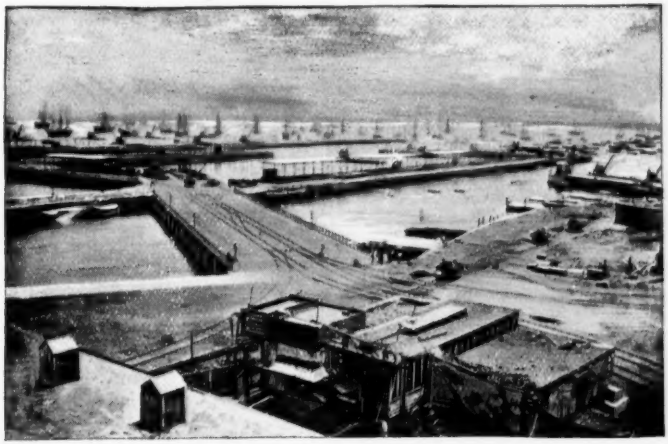
The country is divided, by parallel ranges of the Andes, into four distinct regions: (1) the coast, extending along the Pacific for 1500 miles and inland for fifty miles or more, intercepted by sixty rivers flowing from the cordillera, and fitted for agriculture; (2) the Puna, a tableland 10,000 feet or more above the sea, lying between the western and central cordilleras, abounding in mineral wealth and wool-bearing animals; (3) the Sierra, also a tableland, noted for salubrity of climate, suited to the growth of all cereals and of wool, and containing the chief mining industries; and (4) the Montaña, or forest zone, extending eastward from the Andes, and watered by numerous streams which flow into the Amazon system, thus putting this region in touch with the Atlantic ocean. In this latter region india-rubber and many medicinal plants flourish, and the lands are particularly fitted for the growth of coffee, sugar, tobacco, and spices.

The advantages of railways were so early appreciated in Peru that by 1870 some $29,500,000 had been expended for their construction, but the ill-advised plan of constructing several isolated lines left the country without any commensurate system of communication. One of these lines (the Central) promises, however, eventually to fulfill what was expected of it—to give easy access to important mines and to con-

NOTE.—The limits of Peru are in dispute at so many points that a map satisfactory to everybody concerned remains to be made. The map on the opposite page has been drawn after Steiler, without an opportunity to consult with Mr. Guillaume, who naturally upholds the claims of Peru to wider limits eastward than are indicated on this map.—THE EDITOR.

nect the capital (Lima) with some navigable affluent of the upper Amazon. The extension of this road to Oroya was officially declared fit for traffic on November 14, 1893. The famous Verrugas bridge, destroyed by floods in 1889, has been replaced by a cantilever steel bridge built by a New York firm. The engineers have pierced the

A STREET SCENE IN THE CITY OF LIMA.



HARBOR AND DOCKS AT CALLAO.

mountains with no fewer than sixty tunnels, and the locomotive finally makes its way through the Andes, eighteen miles from Callao, by the Galera tunnel, which is 3800 feet long, at an altitude of 15,660 feet, being the greatest elevation in the world at which a piston-rod is moved by steam. Within a radius of thirty miles from Oroya are several important towns and the famous Cerro de Pasco mine, while it is only sixty miles eastward to the navigable river Perene, which flows into the Ucayali and through that into the Amazon. The Peruvian Corporation, Limited, who now control the line, have the right to extend it to this or some other river outlet, and this offers great hope to the republic. Already the energetic people of the Tarma and Jauja valleys have begun to transport their cattle and coffee to markets on the coast by this line, giving a great stimulus to trade in those regions.

The Southern railroad has also become an important line, extending from the seaport of Mollendo to Arequipa (107 miles); thence to Puno, on Lake Titicaca (218 miles); and from Juliaca to Sicuani (116 miles). Eventually the railroad is to be completed to Cuzco, the former capital of Peru, beyond which are the rich gold-fields of Paucartambo and the india-rubber and other forests of the Madre de Dios. From the Puno terminus there is communication by steamers on Lake Titicaca with Bolivia, to be extended down the river Desaguadero, when the improvements by dredging now under way on that stream have been completed.

There are five other state railways which were ceded by Peru to

A VIEW OF THE CITY OF LIMA.

her creditors under the Grace contract, in 1889, having an aggregate length of 242 miles. There are also five privately-owned railway lines, which, though aggregating only 124 miles, serve an important purpose in the conveyance of the produce of the rich coast valleys to

THE CATHEDRAL AT CUZCO.

the nearest ports. In connection with these, many tramways have been laid for conveying sugar-cane and ores to the railways. Other favorable lines have been surveyed, and the government is likely to encourage their construction in a substantial way.

The Central railroad, so far as completed, has already proved the inestimable benefits of internal communication. The colony in the Chanchamayo valley, established by the government twenty-five years ago, now cultivates some 4000 farms, devoted chiefly to sugar-cane and coffee, the latter of which is expected to yield during 1894 some 60,000 quintals, of a quality which is in growing demand. The German colony of Pozuzo is also rising into prominence after many years of isolation for the want of roads. The Peruvian Corporation, Limited, have located on the river Perene some of the lands ceded to them under the Grace contract, and, for the benefit of the colony

A STREET SCENE IN IQUITOS.

formed on them, the company have greatly improved the roads leading in this direction from Oroya and constructed fine wire suspension bridges over the rivers.* Thus what was formerly an arduous and hazardous mule journey of eight or ten hours has been reduced to two hours, and the charge for transportating merchandise has been reduced 80 per cent. Before entering into possession of these lands the Peruvian Corporation caused reports to be made upon them by Messrs. Ross and Arthur Sinclair, two well-known Ceylon planters, and Mr. P. D. G. Clark, curator of the royal botanical gardens at Peradeniya. The pioneer work was entrusted to Mr. Robert F. Mackenzie, C.E.,

* That over the Colorado has a span of 160 feet and that over the Paucartamayo a span of 260 feet.

PORT MELLENDO.

who employed from 100 to 500 men for eleven months repairing existing roads and constructing thirty-five bridges. The roads are now the best to be found in South America. The territory occupied here by

THE MOLE AT PUNO.

the Peruvian Corporation comprises 1,250,000 acres, extending forty miles along the Perene, and for 12½ miles on each side of that stream. The climate here has proved to be healthful, and among the colonsts are to be found English, Norwegians, French, and Italians. The Indians here are peaceable, and, under proper supervision, make very good workers. There is every indication that in this and other similar regions there will shortly be a large demand for machinery for the preparation of coffee and cacao, sugar-mills, and general merchandise, including many articles of luxury, which the sale of coffee, the coming principal article of export, will enable the people to purchase.

In the opinion of many intelligent observers, the navigation of

THE STEAMER "YAVARI" ON LAKE TITICACA.

the rivers of eastern Peru, converging into the Ucayali and through it into the mighty Amazon, must be regarded, not merely as an alternate outlet for the produce of this region, but as the most direct and economical route to Europe, and, consequently, the railways over the Andes will in time exist mainly for the passenger traffic. The Ucayali is accessible from eastern Peru by two routes. Its tributary, the Pachitea, is navigable for its whole length, besides which the two principal affluents of the Pachitea may be ascended by steamer,—the Palcazu to Mayro (a little below the Pozuzo settlement) and the Pichis to Pardo. The Ucayali may also be reached by the Tambo, which is navigable at all seasons by steamers of 600 to 1000 tons as far up as the junction

A BRIDGE ON THE PUNO RAILWAY.

of the Perene, already mentioned in connection with the Peruvian Corporation concession.

The outside world knows little of the steamer trading which exists already on the streams here named. Every year considerable quantities of freight from these waters is conveyed by steam-launches to Iquitos, the capital of Amazonian Peru, whence it is reshipped for Pará, at the mouth of the Amazon—a distance of 2251 miles—to be despatched to American and European markets after having completely lost its identity of origin. Custom-house returns at Iquitos show the yearly shipment from that port of nearly $750,000 worth of india-rubber, mainly from the Ucayali, Pichis, Pachitea, Tambo, and Perene, for which payment is made chiefly in cottons, cutlery, hatchets, and provisions. At the junction of the Perene and Tambo, for instance, a firm of rubber-gatherers are located, employing 2000 Indians and running some small steamers, which they own, to Iquitos—a distance of about 900 miles. There are many other similar stations, devoted to the india-rubber and other industries, including some on the upper waters of the Huallaga, another important tributary of the Amazon. There is a monthly steamer-service as far down as Yurrimaguas, on the Huallaga, whence other steamers connect with the Amazon. Some of these stations have been stocked with cattle, carried on men's backs over the mountains when young. Almost everywhere there

THE NEW BRIDGE AT AREQUIPA.

is an opening for the introduction of small river-steamers of the type which American builders have constructed for the rivers of Colombia, and which are better suited for their purpose than many of those now used in Peru. On these rivers the petty trading must soon give way to more dignified commercial transactions, and barter will be supplanted by the export of valuable agricultural products which

CROSSING THE PAUCARTAMBO ON THE TELEFORD, 1893.
[A new suspension bridge of 260 feet span now stands here.]

A COLONIST AND FAMILY ON THE RIO PERENE.

should even now be finding their way to European markets. The Peruvian government, recognizing the future importance of this feature of development, has placed itself upon record in encouragement of the extension of river navigation.

The sugar production of Peru, already important, promises to be largely augmented when modern machinery and economical workings are more generally adopted. Owing to the introduction of improved machinery on some of the larger estates, the output of 1891 was 20,000,000 pounds greater than in the preceding year. No other country in the world combines such favorable conditions as does the coast of Peru for the growth of the sugar-cane. Not only is the soil of surpassing fertility, but the absence of rain in this region permits the cultivator, by means of irrigation canals, to supply the exact amount of moisture needed by the plant, and at the time when most beneficial to it. The climate is dry and warm, and so equable that one crop of cane follows closely upon another, so that the sugar-mills can be kept constantly running, instead of remaining idle for months as in the West Indies. Many Peruvians have made large fortunes in sugar, and their estates are models of what a sugar-estate should be. The Tuman estate, belonging to the sons of the late president, Don Manuel Pardo, in the Chiclayo valley, is a very encouraging example of the success attending the introduction of modern appliances. Many other properties are fitted with the latest machinery, principally supplied by English firms, though others have been fitted by Americans, French,

and Germans. They often have extensive tramways which bring the cane to the sugar-house from the fields, and the electric light is used. A considerable portion of the sugar product is converted into rum for home consumption and for export to the neighboring republics. The value of the sugar-estates in the Santa Catalina and Chicama valleys is estimated at over $25,000,000, although until 1866, when irrigation was commenced there by Don Louis Albrecht, who discovered the existence of an old Inca aqueduct and repaired it at a cost of $8000, the Chicama valley was practically a desert. It is expected that during the next few years many sugar-estates will pass into the hands of English companies, as has been the case with the Cartarvio estate of the Messrs. Grace.

Cotton is grown profitably at many points along the coast, but principally in the northern department of Piura. The indigenous species known as "rough Peruvian," grown in the time of the Incas and still found enveloping bodies taken from the ancient tombs, is unrivaled by any other cotton known. It is obtained from a large tree which continues to yield from thirty to fifty years, and in favorable seasons two crops per year may be gained. The average yield on the plantations is 300 pounds per acre, after deducting the weight of the seed. The cotton exported goes to England, where it commands a high price for the reason that, when woven with wool, it is exceedingly difficult to detect the cotton fibers. Indeed; it is claimed to greatly

THE NEW ROAD TO THE PERENE, FROM LA MERCED.

A SCENE IN THE POZUZO VALLEY.

increase the strength and durability of woolens, to prevent shrinkage, and, in the case of dyed goods, to take fast colors. Not only are cotton-mills being erected in Peru with a view to stopping the importation, at least of the coarser cotton goods, but cottonseed-oil mills are

VIEW OF LA MERCED AND THE RIO CHANCAMAYO.

A SUGAR-ESTATE IN THE CHANCHAMAYO VALLEY.

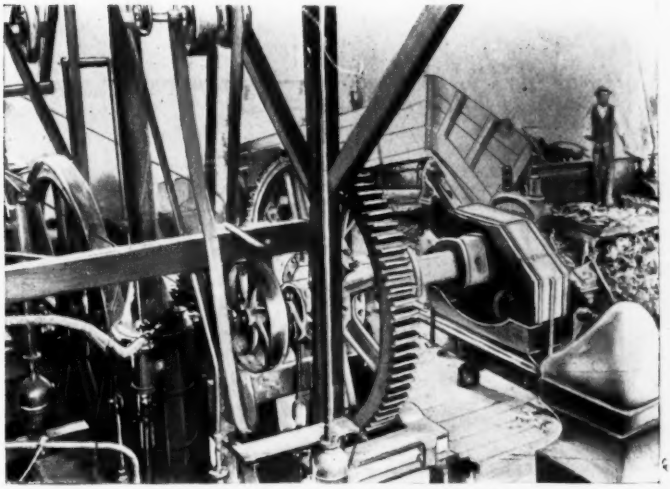
in operation, the product being used in large quantities in the manufacture of soap.

The coffee production has not long equalled the domestic demand, but of late it has increased until some has been exported. Its quality has attracted such favorable attention that foreigners are beginning to settle in Peru to become coffee-planters. All the cereals, tobacco of excellent quality, the ramie-plant, and many other crops may be cultivated with profit. In addition, the wool-growing industry has made a beginning that cannot fail to lead to an important source of wealth, and, in the near future, to the establishment of manufactories for the coarser products of wool.

From recent explorations it is believed that Peru contains the second largest petroleum area in the world, much of it situated in close proximity to the coast, and the fact that the oil is found nearer the surface than in other countries offers a favorable condition. The discovery of petroleum will permanently benefit the industries of Peru, as oil has already supplanted coal as fuel on the railways and steamers and in some of the smelting-works, an economy which may be gaged by the fact that the steam-coal previously used had to be imported from England. An important petroleum deposit exists in the department of Piura, where a zone examined by a United States engineer, Mr. E. P. Larkin, comprises an area of 4,400,000 acres, which is larger than that of Pennsylvania, which produces 84,000,000 barrels

THE TUMAN SUGAR-ESTATE.

of oil annually. Petroleum is found in other departments, and is believed to extend more or less throughout Peru. The wells which have been bored do not as yet exceed 800 feet in depth, and oil frequently is struck at thirty feet below the surface. By making the wells deeper the oil seems more likely to rise without the aid of pumps, forming fountains, some of which have flowed regularly for months or even years. In the department of Piura forty-four wells are producing. At Zorritos one well has yielded oil for seventeen years, and there are wells in this region which yield from ten gallons to eighty barrels per hour. Peruvian refined kerosene has received several gold medals at several great exhibitions. Refineries are being erected at various points, but the progress at Talara has been most rapid, the buildings and machinery being of the first order, forming, together with a lighthouse, wharf, electric-light plant, and telegraph- and telephone-services, the best establishment in South America. It is in the hands of an English company with a capital of $1,250,000, and there are now fifty wells producing oil on this property. The company own a special tank steamer for the shipment of the oil. Some shipments have been made to Shanghai, and it is hoped that the beginning thus made will lead to an important trade with China and Japan. Many other companies have been organized, or are in process of organization, and, there now being no doubt of the abundance of petroleum in Peru, the



MACHINERY AT THE TUMAN SUGAR-ESTATE.

hope is entertained of an important advantage from the fact that Peru is nearer to Japan, China, New Zealand, and Australia than is any part of the United States.

HAULING SUGAR-CANE ON A TRAMWAY.

LADIES AND GENTLEMEN OF LIMA GIVING A CONCERT FOR A CHARITABLE PURPOSE.

Of the mineral resources of Peru, themselves constituting a vast source of wealth, the prospective development of which has served to stimulate the development of the railways, and which might reasonably be expected to be of interest to mining engineers and to the manufacturers of mining equipment in the United States and elsewhere, there is much to be said, but as the space allotted to this paper is necessarily limited, and as the writer understands that the Magazine has in hand from other contributors something bearing upon this subject, it will not be farther touched upon in this connection. Another subject of importance to the engineering world is the vast system of irrigation, by means of which agriculture was a profitable pursuit among the ancients, and the revival of which, now in progress on a large scale, promises much for the future of the country. The latter subject alone is worth treatment to the extent of a separate article in the Magazine.

It may be of interest here, as indicating the extent to which Peruvian commerce has already grown, to give the latest available returns of exports from the seaports, which cover the year 1891:

Agriculture—		
Sugar	$3,169,449	
Cotton	1,214,140	
Medicinal leaves	345,830	
Rice	150,220	
All other	341,482	
		$5,221,121
Animal Industry—		
Live and dead animals	$188,747	
Hides	294,388	
Wool—Sheep	304,650	
Alpaca	557,181	
Vicuña	15,746	
		1,360,712
Mining—		
Silver	$3,681,355	
Gold	103,623	
Copper	3,817	
Marine salt	404,813	
		4,193,608
Manufactures—		
Flour	$230,534	
Straw hats	183,861	
Wines	103,541	
Boots	33,148	
Lubricating oil	33,092	
All other	90,210	
		673,586
Miscellaneous		170,690
Reëxports		751,409
Total exports		$12,371,126

The exports and imports, divided among the various countries sharing the trade of Peru * during the same year, were as follows:

COUNTRIES.	Exports.	Imports.
England	$5,811,973	$6,289,380
Germany	1,111,457	2,865,760
Chile	1,190,479	1,103,274
France	354,234	1,576,587
United States	278,015	1,323,875
All other	3,624,967	2,007,551
Total	$12,371,126	$15,166,427

In conclusion, the question arises: Who shall have the Peruvian trade? England,—rich in colonial possessions and with markets all over the universe open to her,—Germany, and France are still extending their colonial empire, and dividing among themselves the map of Africa. The United States, on the other hand, with no colonial policy to pursue, have become nearly foremost in the manufacturing world, and need to establish new commercial relations that their manufactured articles may have a ready market. Here such a market lies at their very feet; whether they will obtain here the outlet which they desire time alone will prove, but of the country's vast resources I can quote nothing more appropriate than the words of the late Professor James Orton, himself a North American, who was an enthusiastic and extensive traveler in Peru:

"Peru has immense capabilities. She is the France of the South American continent . . . These rich resources, lying almost at our very doors, must soon appeal to that restless spirit of enterprise and commercial activity which, not content with its vast triumphs, longs for new conquests and a wider field of exercise. One looks forward to the dazzling future of this great valley, when the ships of all nations will crowd the network of rivers for the gold and perfumes, the gems and woods of the great western Ophir."

* No account is taken here of the commerce of Iquitos, of which mention has been made elsewhere in this article. H. G.

BREAKWATERS, SEA-WALLS, AND JETTIES.

DESIGNS AND COMMERCIAL IMPORTANCE.

By George Y. Wisner, M. Am. Soc. C. E.

THE history of the material and commercial progress of any country is identical, to a great degree, with that of the development of inland transportation and the establishment of terminal ports of easy access for foreign commerce. The home value of the products of manufacturing and agricultural enterprises is the price they will bring in the markets of the world, less the cost of transportation; consequently any decrease in transportation rates adds a like amount to the value of all productions, whether for export or for home consumption, and gives the producer a corresponding advantage over those of competing countries.

The secret of cheap transportation lies in the ability to handle and carry large quantities of freight for long distances without change. This being the case, the commercial interests of a country require that the development of the means for interior transportation and for safe and commodious harbor facilities for foreign commerce shall form links of the same general system of improvements. The demand in commercial countries for deep-water outlets is such that millions of both public and private funds are expended annually to develop whatever natural facilities may exist, and the maintenance of such channels, when obtained, depends largely upon properly-designed systems of breakwaters and jetties.

England, with scarcely any portion of the country more than a hundred miles from a good harbor, has maintained her maritime supremacy with little to fear from any of her commercial neighbors except the United States, where the admirable system of inland waterways renders the cost of interior transportation almost as cheap as that of ocean traffic. The magnificent coastline of England is studded with harbors which, where the natural depths were insufficient for the commerce of the ports, have been improved and protected by sea-walls and breakwaters from wave-disturbance and from deterioration from deposits of sand-drift. In France, the principal maritime harbors are artificial and the structures are monuments to the engineering genius of that nation. Germany, with a great natural system of inland waterways, has but few maritime ports of importance, and would no doubt be glad to increase her facilities for foreign commerce by taking the harbor-lined coast of Holland under her protecting care.

Russia has watched the coasts of Turkey with covetous eyes for years and, failing to obtain these valuable outlets for her commerce, is now building a railroad across Siberia to her deep harbors on the Pacific, which eventually will bring her in such close connection with China that careful observers are inclined to think it will result in a large slice of the Celestial empire becoming subject to Russian rule.

The improvement of harbors in the United States extends only over a period of about ninety years, during which time upwards of $250,000,000 have been expended by the general government for such purposes. About $40,000,000 of this has been used for improving the harbors and waterways of the great lakes, where the system of jetties and breakwaters for improving harbors is perhaps more general than on any other coast in the world. The average extent that the lake harbors and connecting waterways have been deepened is approximately eight feet, at an average cost of $5,000,000 for each foot gained in depth. This may seem somewhat expensive, but, when the cost is considered in connection with the benefits derived, it is a mere bagatelle.

Prior to 1871, the ruling depth of lake ports and connecting channels in the United States was about 11 feet, which was then increased to 13 feet. In 1873 the depth was increased to 16 feet. The freight-rate on grain from Chicago to Buffalo, before the channels were deepened, averaged about 8 cents per bushel, but the rate has since decreased to less than 2 cents. The grain delivered at Buffalo in 1892 amounted to 182,000,000 bushels, on which the cost of transportation was $11,000,000 less than it would have been with the freight-rates prevailing before the channels were deepened. Since the grain freight amounts only to about one-fourth of that affected by the cheaper rates, it is evident that the amount saved to producers in a single year is nearly as much as the entire improvements of lake channels and harbors have cost. The rapid growth of American commerce, the vast coastline to be improved, and the limited funds to be had for such purpose, created a demand for immediate results at small expense, which in many instances has necessitated the construction of works of a temporary character. The replacing of such works with permanent structures, which will at the same time increase the harbor facilities, are problems well worthy of careful consideration.

The general system of breakwater construction on the lake-coasts has been that of timber cribs filled with stone. In the lake climate the average life of timber above water is about eleven years, and, with the low cost of lumber during the early years of harbor improvement, renewals of superstructures could be made for an amount less than the interest on the investment needed for permanent structures. The in-

crease in the cost of lumber has so changed this ratio that it will be more economical in the future to make use of more lasting material for construction purposes. These structures below water-level are generally in good condition for making foundations for permanent concrete superstructures, the sections of which should be so designed that wave-shock will be a minimum. The only serious failure of such works which has occurred recently was that at Buffalo harbor, last year, where a new structure costing upwards of $100,000 was washed away in a single storm. In this case, however, the government engineers refuse to give any information as to the character of the construction or the cause of the failure, which would indicate that it was due to faulty engineering.

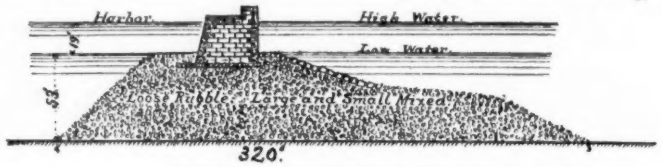
On our sea-coasts various devices have been tried to avoid the expense of rock and masonry construction, but, with the exception of the brush jetties at the mouths of the Mississippi and Brazos rivers, where the sediment from those streams protect the works from the ravages of the teredo navalis, little now remains of the original structures. Where such works are being rebuilt, riprap is generally used, built into mounds and allowed to assume a natural slope under wave-action, similar to the breakwaters at foreign ports, of which a few typical examples are named in the following table:

NAME.	Kind of Work.	Depth of Water.	Sea Slope.	Width of Base.	Cost per Lineal Ft.
		Feet.		*Feet.*	
Portland	Rubble mound with masonry above low water.	50 to 65	5 to 1	270	$ 600
Holyhead	Rubble mound with masonry above low water.	20 to 50	12 to 1	460	950
Plymouth	Rubble mound.	40 to 50	5 to 1	360	1,000
Dover	Solid masonry.	40 to 60		82	1,800
Algiers	Rubble mound with slopes of large Beton blocks.	30 to 90	1 to 1	250	600
Cherbourg	Rubble mound with masonry above low water.	50 to 70	7 to 1	320	1,080
Marseilles	Rubble mound with slopes of large blocks. Concrete parapet.	30 to 60	1 to 1	260	540
Colombo	Concrete blocks on rubble mound.	20 to 40		130	600
Delaware Breakwater	Rubble mound.	30	1½ to 1	160	530
Sand Beach, Lake Huron	Timber cribs filled with stone.	30		38	175

The sea-slopes given in the table, which the loose rock has taken under wave-action, are those at or near low water. In depths of over twenty feet below low water the slope is usually greater than two horizontal to one vertical.

At Portland, Holyhead, Plymouth, Cherbourg, and Delaware breakwater the products of the quarries were used directly as broken up by blasting, without regard to placing the different size of rock where its resistance to movement would be sufficient to withstand the sea forces without assuming such low slopes as to make the width of structures unnecessarily great. Since the force of waves tending to move any obstruction increases as the area of the exposed surface—or as the square of one side of the block—and the resistance to moving as the cube of such dimension, it is evident that, if the larger blocks of rock be placed so as to receive the heaviest shocks from the waves, a much steeper slope may be maintained, and consequently a much narrower structure be made to accomplish the purpose required.

Placing material in the works with the respective sizes so arranged as to resist wave-action in the best manner increases the amount of

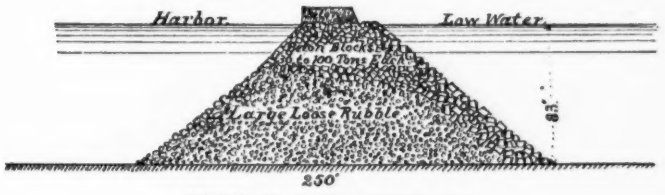


SECTION OF CHERBOURG BREAKWATER.

void in the structure, and correspondingly decreases the amount of rock required. With fine and coarse material dumped into a jetty as broken up in the quarry, the voids in the mound may not exceed 10 per cent. of the volume, whereas, if placed with regard to size, the voids will exceed 30 per cent., and such arrangement will consequently reduce the amount of material required by more than 20 per cent.

English engineers seem to have adhered to the same general system in nearly all their works of this kind, but the French, after the construction of the Cherbourg breakwater, saw the error of their ways, and used the smaller rock for a core of the mound and the large blocks for protecting the slopes where exposed to the impact of waves. The economy of this method of construction is very clearly shown by the work at Algiers, where the depth of water was 50 per cent. greater than at Cherbourg, while the width of structure required was only two-thirds as great, and the cost per lineal foot only a little more than one-half.

The forces to which breakwaters are subjected from impact of waves

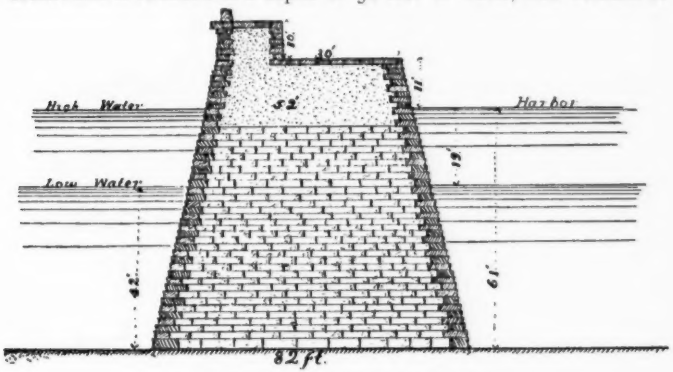


SECTION OF ALGIERS BREAKWATER.

are sometimes enormous, and in many cases are actually increased by the form given to the structures. In deep water the motion of a particle is a closed curve, in which the forward motion in the crest of wave is somewhat in excess of the backward movement in the depression, producing a general surface resultant in direction of the wind. When any obstruction is encountered the wave-motion is converted into one of translation, such that the striking force is sometimes several tons per square foot.

Below the plane of wave-disturbance the effect is simply one of pressure, but from thence to the surface the power to destroy increases very rapidly. At Colombo, Ceylon, waves 15 feet high in 40 feet depth of water have been observed, in breaking against the breakwater, to throw spray 120 feet to 150 feet high, indicating a pressure from wave impact of from four to five tons per square foot. At Cherbourg the height to which spray is thrown shows a striking force nearly as great as at Colombo, and on several occasion has resulted in serious damage to the superstructure.

At the harbor of Wick, on the northern coast of Scotland, the breakwater is founded in a depth of 50 feet of water, and consists of

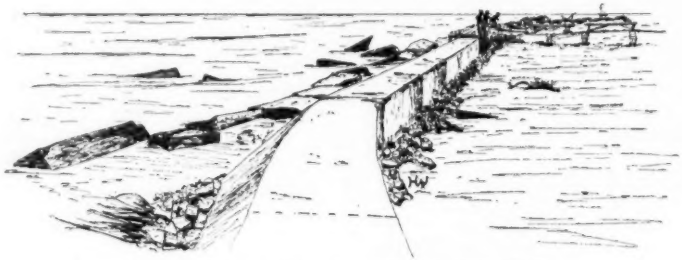


SECTION OF DOVER BREAKWATER.

a concrete superstructure built on a rubble mound 18 feet below low-water level. During a storm in 1873 a considerable portion of the concrete wall was wrecked, and a single piece of over 1500 cubic yards was moved bodily out of place.

Where the riprap foundations, on which such structures are usually founded, have a low slope, a motion of translation is given to the wave before reaching the wall which greatly increases the striking force. To reduce the impact of the waves to a minimum the slope below surface of sea should be made as steep as possible and the outer face of the superstructure so far inclined from a vertical that the wave-pressure will be downward instead of horizontal.

The principle asserted by English engineers in favor of vertical walls for breakwaters is that oceanic waves in deep water are purely oscillatory and exert no impact against vertical barriers which, consequently, have only to withstand the hydrostatic pressure due to the height of the impinging waves. The wreck of many important works, however, has shown the fallacy of this conclusion.



NEW CONCRETE WALL AND JETTY AT SOUTH PASS.

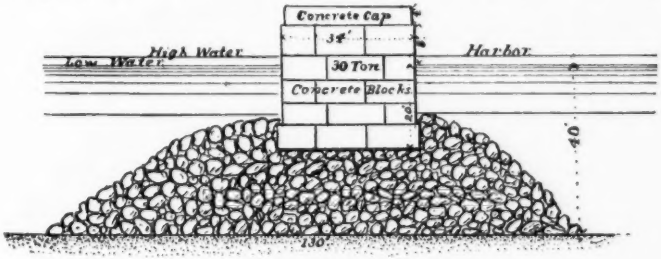
[Wreck of the old Eads wall and jetty at the left.]

The accompanying cut of the new concrete sea-wall and the wreck of the old wall, at South Pass, very clearly illustrates the results of the two plans of construction. The original wall, built by Captain James B. Eads in 1879, had a vertical face towards the sea of about five feet, and was partially wrecked within a year after being constructed. The new wall, built by the writer in 1889, contains less material per lineal foot than the original structure, and has withstood some of the most severe storms ever experienced on that coast without being damaged in the slighest degree.

The breakwater at Colombo harbor is of typical English design, and, while it has withstood the tremendous shock of the waves for ten years, such result is more due the substantial method of construction than to being designed so as to reduce wave impact to a minimum.

The exposed portion of the breakwater is in 40 feet of water, and is constructed of 30-ton concrete blocks, surmounted by a concrete cap 4 feet thick, and is founded on a rubble mound 20 feet below sea-level. The concrete blocks are set at an angle of 20° from the vertical, in direction of the axis of the breakwater, and have grooves at the joints, which, when the wall was completed, were filled with concrete, making the structure practically monolithic. If from low-water surface the breakwater had been given a slope for half the width of wall, a large amount of costly material might have been saved and the shock from wave impact greatly diminished.

The functions of jetties and breakwaters are usually threefold: (1) to concentrate river and tidal currents through the proper entrance channels; (2) to prevent sand and littoral drift from entering and being deposited in the harbor; and (3) to form shelter from heavy



SECTION OF COLOMBO BREAKWATER.

seas for the safe entrance and anchorage of ships. In a majority of cases the deterioration of harbors is largely due to the movement of sand parallel with the adjacent shores, from wave and current action, and, if the structures are not so designed as to prevent such drift from being deposited under the shelter of the works constructed, they are certain to result in total failure. Littoral currents alone are not generally of sufficient force to produce erosion, but, when aided by wave-action, the drift is picked up and transported along the coast until some shelter is found where wave-disturbance is not strong enough to hold the particles in suspension. Unfortunately, this condition often occurs behind breakwaters designed for the protection of harbor-entrances and anchorages.

A fair example of such faulty design is shown by the rapid shoaling which has taken place in the great harbor of refuge formed by the Delaware breakwater, completed in 1869 at a cost of $2,750,000. The anchorage sheltered by the breakwater was from 25 to 30 feet deep when the work was completed, but has gradually shoaled so that

at present there is but little of the protected area over 16 feet deep, or, in other words, the harbor is practically worthless for the purpose for which it was constructed.

At the recent International Engineering Congress Mr. J. P. Griffith, of Dublin, said:

> The keynote to the success which has attended the efforts made to improve the Dublin bar has been due to a full appreciation of the littoral and tidal currents by the engineers who designed the works. Dublin bar has been improved by artificial scour resulting from the construction of a tidal reservoir of 2500 acres, enclosed by two great piers extending out over the strands of Dublin bay. These piers have been so formed as to make the outward scouring current flow in unison with, *and not in opposition to*, the littoral currents of the bay.

The failure to fully appreciate the effect of littoral currents by engineers has been the cause of their adopting plans for improving several important American harbors which have totally failed to produce the results anticipated and predicted. The design for the improvement of Galveston harbor by means of jetties is a notable example of this class of work. The general direction of the littoral drift on that coast is from the northeast to the southwest; yet the jetties, on which upwards of $4,000,000 have already been expended, are faced directly to the eastward. The results thus far obtained have been an increase of channel depth on bar of about two feet, an abnormal movement seaward of the outer face of the bar, and the development of an eddy to the south of the works of such magnitude that the city front has been washed away in places a width of nearly 1000 feet, while, during the past ten years, the loss of nearly sixty acres of city property has occurred. The problem that now confronts the citizens of the Island City is, whether they will have any city left by the time a deep-water channel is obtained across the harbor bar.

GOLD-DREDGING IN NEW ZEALAND.

By T. A. Rickard, F.G.S.

THE south island of New Zealand is the Switzerland of the antipodes. The warm, wet winds of the Pacific, arrested by the lofty mountain-ranges that guard the western coast, are compelled to precipitate their moisture for the maintenance of the snow-fields, glaciers, and fresh-water lakes whose varied beauty excites the wonder of the traveler and the admiration of the artist.

The melting snows feed streams the volumes of whose waters enables them to rank among the great rivers of the earth. The most important is the Clutha,* with its tributaries the Shotover and the Kawarau. This noble river flows through the province of Otago, and to the dwellers in that gold-mining region it is what the Nile is to the Egyptian fellaheen. The Clutha does not, it is true, flow through lowlands of great fertility, but it washes the rocks of gold-bearing highlands, and the mud which enriches the flat plains of the delta is comparable to the tribute of golden gravel brought down from the hills by the more rapid waters of the southern river. The anxious cultivator in the land of the Pharaohs does not watch the rise and fall of the historic river of the north with greater anxiety than does the miner the swollen torrent of the stream whose quick rise or gradual fall may mean either the cessation of work and the flooding of his working ground, on the one hand, or the ingathering of a golden harvest, on the other.

The names of the Clutha and its tributary streams are interwoven with much of the early history of gold-mining in New Zealand. It was at Gabriel's Gully, near Tuapeka, in June, 1861, that the discovery was made that started the flood of immigration and woke into activity the land which Captain Cook had discovered nearly a century before. Since 1861 New Zealand has yielded about 12,000,000 ounces of gold.† Of this a large share has come from the gravel lying along the banks of the rivers of the south island. The mountain streams flow through dark ravines threading an alpine land whose lofty ranges are forever crowned with snow. Lakes are common and their waters are marvelously clear and deep. The bare ridges which they reflect have a coronet of snow which is their only claim to nobility of aspect. Approaching the sea, the rocky gorges give place to narrow valleys of pastoral land and rolling foothills whereon multitudinous flocks of sheep fight for existence with the rabbit, the pest of the colonies.

*Also called the Motyneux.

†The production for the year 1892-1893 was 228,659 ounces.

The rock of the upper country, the miner's domain, is for the most part a schist, a fissile soft rock, diversified by innumerable seams of quartz which give it a characteristic foliated or "leafy" appearance. It is to the rapid weathering of this rock that is due the configuration of the country and the enormous quantity of gravel transported, and afterwards accumulated, by the rivers.

The chief agent in this work of degradation is the frost, which to the gold-miner is what the earth-worm is to the farmer. One disintegrates the rock, the other turns over the soil. A little drop of the rain of heaven penetrating a crack or cranny becomes slowly contracted by lowering of the temperature until 4° C. is reached, when it expands suddenly so as to serve as a resistless lever to which the rock, however adamantine, must perforce yield. At high altitudes the difference between the temperature of the day and the night is very marked. To it are due the severest hardships of mountaineering. The action of frost is therefore increased, and, in a fissile rock like the schist of Otago, there is afforded a material peculiarly subject by its structure to easy degradation.

The schists contain gold, sometimes confined to distinct seams or veins of quartz, but more commonly and more widely disseminated through certain portions of the rock formation within belts or areas whose boundaries are indefinite and indeterminable. Such deposits of gold are rarely valuable to man because the quantity per ton of rock is too small for profitable exploitation; but nature, in her slow and patient way, has done what man often tries to do in a clumsy and hurried manner,—that is, concentrated the values so that they have become economically important. The wind and rain sweep the fragments of the rock already shattered by the frost into the stream, which hastens to deliver them to the river. The waters of the river separate the heavy particles from the light and in so doing assort the valuable from the valueless. Wherever the swiftness of the current is retarded the heaviest particles are deposited while the lighter sands are borne along to the distant sea. Thus the gold becomes laid down behind projecting bars or under the shelter of rocky bends.

The river Clutha affords many instructive lessons in physical geography. It is comparable to a "ground sluice." The miner, when he is working a deposit of gold-bearing gravel, takes his pick and shovel and cuts out a channel (two to three feet wide and one to two feet deep) in the underlying solid rock (the "bed rock"). This is called a "ground sluice." He then proceeds to conduct a stream of water under pressure by means of a pipe against the face of the gravel, washing it down into the sluice. The ridges, hollows, and other irregularities of the rocky bottom serve to arrest and collect the gold,

while the water carries away the lighter, valueless material. Sometimes this arrangement is impracticable; so he makes a wooden launder or box whereby to conduct the gravel and water; across the bottom of this he places strips of wood or uses other devices to impede and interrupt the current and permit of the settling of the gold. Such a launder is a "sluice-box" and the traps for the gold are called "riffles" (America) or "ripples" (Australia).

The Clutha, with its seven-knot current, sweeps down through the easily-eroded rocks into which it has cut for itself a natural sluice-way, the riffles of which are the rocky bars, while its head is at the feet of the glaciers and its lower end empties into the Pacific. Its course is characterized by a succession of narrow gorges followed by wide flats. Where the river now flows there was once a chain of fresh-water lakes cut out by the glaciers which have since receded further inland. These lakes in a bygone geologic period received the tribute of the upper highlands in the form of the gold-bearing gravel which was laid down in their quiet depths. In later times the Clutha worked its way from lake to lake, and, having finally worn down its channel deep into the rock, it emptied the lakes, cut through the deposits which they had accumulated, and now flows unfettered to the sea.

The first gold-seekers who, in 1861, explored the sands of the Shotover and the Clutha, restricted their search to the easily-accessible deposits of gravel which the work of centuries had accumulated in sheltered places. When the gold-bearing sands were found to extend under the main waters of the river they turned the stream by means of artificial dams. This is ordinary placer-mining. The rich alluvium, however, was found to exist in places where it was too costly or even impossible to divert the stream; in such places the digger was compelled to wade knee-deep, and, standing shovel in hand, to snatch with difficulty the golden sand which appeared to increase in richness the less accessible it became. To raise sand from the bed of a stream with a shovel is difficult enough at all times. It is impossible where the current is rapid. The next step, therefore, was to contrive a ladle or spoon with which to scoop up the river-bed. A piece of hide attached to an iron rim was arranged behind the modified blade of a shovel and fastened to the end of a long pole. The territory available for work was thus considerably enlarged; but the exhaustion of the gravel near the banks caused the distance from the shore to be steadily increased. Soon the water became too deep for this kind of work, so a barge or punt was built, the pole was lengthened, the scoop was enlarged, and mere hand-power was replaced by a winch and tackle. This now became what is known as the "spoon-dredge." It served its purpose and had in turn to step aside for something better. The num-

erous hydraulic mines began about this time to send down their débris or tailings, which slowly covered the river-bed with an increasing depth of valueless gravel. The extra work, essentially unprofitable in its character, which this threw upon the spoon-dredge, soon rendered it necessary to invent some better machine. The first step was to replace human muscle by the greater power which went past unexpended in the current of the river itself. The winch was succeeded by the water-wheel. Thus the "current-wheel dredge" was invented. One scoop was replaced by several worked by an undershot water-wheel erected by the side of a barge. The idea was a good one, but its successful application was hampered by the fact that, being adapted only to work in the full force of the current, it could not be utilized in the back-waters, pools, and other places where lay the richest parts of the river-channel. Steam then replaced water-power, the "scoops" or buckets were largely increased in number, and they were so arranged as to work in an endless series. Thus was evolved the "bucket-and-ladder dredge." Further improvement was made by the addition of revolving screens for sizing the gravel, by introducing winches for mooring the barge, and by utilizing pumps for raising the water required to separate the fine gold-bearing sand from the coarse, valueless gravel.

This brings the story of the evolution of the dredge up to the time of my last visit to Otago (1891), when the river-sands and sea-beaches of the south island were being worked by a force of fifty dredges, propelled by water, steam, and electricity. Since then the number has been decreased, owing to the lack of success met with by many of the dredging undertakings. This result is not to be wondered at; the machinery for raising the gravel out of the river-bed is good and efficient, but the devices employed to save the gold are imperfect. When this defect is remedied, the successful dredges, instead of being painfully few, will be very numerous. Space does not permit of a general discussion of this part of the subject; it can be found elsewhere.* For the present it will suffice to describe a typical instance.

The Dunedin dredge was at work on the Clutha at a place called Coal Creek, a short distance above Roxburg. It was one of the first dredges to meet with success and it is still, I believe, giving profitable returns. It is of the bucket-and-ladder type and is bilaterally symmetrical, one side of the machine being a duplicate of the other. It will therefore suffice to describe one side. An "endless" series of buckets, thirty-one in number, is kept going up and down. While the topmost bucket is being emptied the bottom-most is under the water of the river, being filled. Each bucket has a capacity of two cubic feet,

*"Alluvial Mining in Otago," by the writer. Transactions of the American Institute of Mining Engineers, Vol. XXI.

and twelve of them are emptied per minute, so that 53 cubic yards, or 75 tons, are being treated every hour. The dredge as a whole has double this working capacity, since the other side is acting similarly. The buckets empty the gravel into a hopper or "holder," which feeds it into a perforated iron cylinder. This revolves slowly, and, being placed at a slight inclination, carries the large pebbles into an iron chute which ejects them into the river, while the finer sands which have passed through the apertures are sent over a table 8 feet long by 7½ feet wide. This table and its duplicate on the opposite side are covered with coarse cocoanut matting, which is intended to arrest the gold. Both tables have a slope of two inches per foot and discharge into a central table, 8 feet long by 4 feet wide, provided with riffles. From here the gravel falls into the river.

The gold, by the action of gravity, is caught upon the matting. The matting is washed at intervals in a tub. The latter becomes filled with the black iron sand and fine gold which are thus collected. The separation of the gold is effected by washing this material by hand in a miner's prospecting pan.

The working expenses are $1000 to $1250 per month, which includes the wages of nine men and a foreman. The fuel bill is $150. The chief item of expense is for repairs, due to the wear and tear about the buckets.

The dredging of a river-bed in the teeth of a fast current is a work of much difficulty, especially when the two or three feet of gold-bearing wash lies upon an uneven bed and is covered by a valueless overburden of tailings many feet thick. The dredge has a much better chance when excavating "pay gravel" lying upon a "false bottom." Such was the case at Waipori, where the most satisfactory work has been accomplished. Instead of lying on a rocky and uneven bed, the golden material rests upon a layer of barren coarse sand, the true bottom being many feet deeper. The buckets of the dredge can get their lips underneath the "pay" and scoop it up successfully. It is like working with a shovel under water; unless you can get the shovel well under the sand you cannot prevent it from running off. A dredge, after all, is only a multiplied and modified shovel. Steam is usually employed in Otago to give the power necessary to drive the machinery of the dredges. Coal is not expensive. Nevertheless, the mountain streams afford every inducement to utilize a more modern method, to transmute the energy of the waterfall into that of the electric current. This is done by the Sandhills dredge. This dredge began to work at a place about 1½ miles below the generating station, but it has since worked its way above.

When the dredging fever broke out in New Zealand, in 1890, every

river-bank and every sea-beach was thought to be richly gold-bearing. Some of the early successes met with on the Shotover were due to the luck and enterprise of a Chinaman, Sew Hoy. He did so much better than the colonists that one was tempted to put Bret Harte's question and ask whether the Caucasian was played out. Sew Hoy and his dredging enterprises are now a thing of the past, and the Mongol is again represented as digging for that which the white man has left, picking up the crumbs that fall off the Caucasian's table.

Certain places along the sea-beaches of the south and west coasts of the south island have been for many years worked by hand, and are known to be rich in spots. The prevailing winds have concentrated the titaniferous iron sand which carries the gold and which has been brought down by the rivers and distributed by the tides. In certain localities that concentration has progressed so far as to render exploitation profitable. At Waipapa, on the south coast, some successful work was done in spite of many difficulties. A centrifugal suction-pump was employed to gather up the material of the sea-beach, and stones exceeding 30 pounds in weight were successfully elevated by this method. The driven sea-mist does not hide the curving coast-line, but the wind has made ripples in the sands of the foreground and partially, at least, is illustrating the method by which the gold has been concentrated.

This dredge was able for a time to work at a profit sands from which it extracted only two grains per ton, or one part in fourteen millions. Nevertheless there can be no hesitation in saying that neither this nor any other of the dredges succeeds in arresting more than a fraction of the gold contained in the sand and gravel which they raise from the river or sea and return to it. The gold of New Zealand is not of the shotty, nuggety character common to most gold-regions; it consists of minute plates which, when their edges are turned, as must often happen when undergoing rough treatment by a dredge, become especially adapted to floating on water. The minuteness of the gold of many localities, particularly on the west coast, can be gaged by the fact that by actual count it requires 7000 particles to make up one grain in weight.

Is it to be wondered at that the cocoanut matting does not arrest it? No purely mechanical device can be expected to work successfully when working such an enormous quantity of unsized material. Chemical methods—the use of mercury—must be adopted and supplemented by a further sizing of the finer gravel which carries the gold.

At Waipapa plush of the finest quality was employed; elsewhere green baize has been tried. Cocoanut matting, apart from its cheapness, is admirably adapted for gold-saving by mechanical means. The

fibrous rough surface gives opportunity for the gold to become caught. It is interesting in this connection to consider how primitive these gold-saving devices are. They were used under slightly different forms in the prehistoric era, when the Argonauts employed the fleece of the ram to arrest the gold of the river Colchis, and they are typified in the shaggy hides of wild beasts used by the aboriginals of many ancient gold-producing lands.

There is a fascination to the miner in the idea of working river-beds flowing through gold-bearing regions. Such river-beds seem to him to be paved with untold wealth, stored there by nature from her earliest day. There is an element of cold fact in the digger's dream, since the rivers have been the channels for golden gravel for long periods of time. River-dredging in the years that are coming is therefore destined to become of greater importance in contributing its share of the gold whose want is the pain of some, whose superabundance is the curse of others.

CEMENT AND CEMENT-TESTING.

By Spencer B. Newberry.

GREAT progress has been made within the last few years in the manufacture of hydraulic cement. In nearly every kind of construction this material finds application, and many difficult engineering problems have been solved by its judicious use. In hydraulic cement is found an effective means of binding together deposits of loose and insecure materials, thus making them capable of bearing enormous burdens. The great buildings of Chicago, resting upon a deep substratam of plastic clay, are rendered secure by massive foundations of cement and iron. In marine work and the improvement of rivers and harbors the uses of cement on an immense scale are well known. Recently a multitude of lesser applications of cement have been developed, such as its use as a foundation for asphalt and brick pavements, and in the manufacture of sewer-pipe, curbstones, tiles, and architectural ornaments. No modern house is complete without a good cellar-floor of Portland cement. Cement sidewalks also are replacing the more costly and less durable walks of flagstone; in the city of Chicago alone nearly 8,000,000 square feet of cement walk were laid in 1892, requiring 200,000 barrels of cement. In cement we have the *essence of rock* in a portable and convenient form, requiring merely to be diluted with sand, moistened with water, and pressed into place to acquire in a few days the hardness and solidity of the best stone.

The cement used by the Romans consisted of a mixture of slaked lime with *pozzuolana*, a volcanic scoria which possessed the property of making ordinary lime hydraulic. This material and a similar substance from the Rhine, called *trass*, were the only hydraulic materials in use before 1756, when Smeaton built the Eddystone lighthouse. Smeaton made a comparative study of different kinds of lime in regard to their hydraulic properties and discovered that those limestones which contain a considerable proportion of clay yield lime of remarkable hardening qualities. By carefully selecting lime of this character he was able to build a firm and durable structure. Vicat, a French engineer, showed in 1818 that the cause of the hydraulic property is the combination of lime with clay, and, by burning mixtures of these materials, he succeeded in producing artificial hydraulic cement. Many deposits of limestone containing clay occur in England and France, and the manufacture of cement from this material gradually developed. It was later discovered that, in order to give the best results, the lime

and clay must be mixed in very exact proportions and burned at a very high temperature. In this manner a product greatly superior to that made from natural rock was obtained, and to this the name Portland cement was given, from the resemblance in color of the hardened cement to that of the celebrated Portland building-stone. The manufacture of Portland cement has reached great magnitude in England, but within a few years Germany has taken the front rank in the quantity, and probably also in the quality, of her product.

Hydraulic cements are, therefore, compounds of lime with the silica and alumina of clay, and are made by exposing natural or artificial mixtures of carbonate of lime and clay to a high heat and grinding the product to powder. They owe their value for building purposes to their property of hardening, after mixing with water, to a stone-like mass.

If deposits of limestone could be found containing exactly the right proportion of clay, Portland cement could be made directly by burning such natural rock, but this hardly ever occurs. Either the limestone contains too little clay, in which case it is practically useless, or it contains too much, and, if exposed to the high temperature necessary to the formation of Portland cement, it fuses to a glassy slag destitute of hydraulic properties. In the latter case a low heat, just sufficient to drive off the carbonic acid of the limestone, will bring about a partial combination of the lime and clay, and a light-colored, quick-setting cement results. In this manner natural-rock cement—also called Roman, common, quick-setting, or hydraulic cement—is made.

Two kinds of cement may therefore be distinguished: (1) natural-rock cement, made from limestone containing an excess of clay, by burning at a low heat, and grinding to powder; and (2) Portland cement, made from an artificial mixture of chalk, marl, or ground limestone, with exactly the right proportion of clay, by burning at a white heat and grinding the resulting clinker to powder.

Portland cement is heavy, slow-setting, and greatly superior to natural-rock cement in strength and hardness. Owing to the greater labor required in its manufacture it is much more expensive than the common cement, and the latter is generally employed in this country for all purposes in which great strength is not essential. In Europe, however, the manufacture of natural-rock cement has practically ceased, Portland cement having proved cheaper to use, in spite of its greater cost, owing to the much higher proportion of sand that it will carry.

In the United States natural-rock cement is manufactured on an enormous scale, nearly 8,000,000 barrels of it having been made during the past year. The industry was first established at Rosendale, on

the Hudson river, and in that neighborhood there are now seventeen factories, producing more cement than is made in any other locality in this country. The rock used in the Rosendale region is the limestone lying at the top of the Salina group, the outcrop of which extends along the Hudson river nearly to Albany, then turns westward, and is exposed at various points as far as Buffalo. This rock is a highly magnesian limestone, and contains a considerable proportion of clay. Cement is made from the same rock near Syracuse, and also very largely at Akron, Erie county, N. Y. The process of manufacture followed in the Rosendale region is very simple. The rock is quarried and burned exactly as in making common lime, continuous kilns being generally used. The calcined rock is of a yellowish or brownish color, and does not slake with water, the lime being chiefly in combination with the silica and alumina present. The burned rock is crushed and finely ground, and is then ready for use as cement. Other regions where natural-rock cement is extensively made are Louisville, Kentucky; Utica, Illinois; Milwaukee, Wisconsin; and Lehigh county, Pennsylvania. The product is known by various names, according to its place of manufacture, the best-known kinds being the Rosendale, Akron, and Louisville cements.

Natural-rock cement often shows remarkable hardening properties, but its chief defect is lack of uniformity. It is used on an immense scale for common purposes, as in the foundation of street-pavements and for building-mortar, and also in the lining of cisterns, reservoirs, and aqueducts. It has not sufficient hardening power to answer for sidewalks or flooring, and should not be used in foundations and masonry requiring great strength. The production of the natural-rock cement is so great that the price has fallen to a very low figure, much having been sold during the past year at not more than 25 cents per barrel, in bulk, at the works.

Portland cement, as already explained, is made by burning an artificial mixture of carbonate of lime and clay. Any pure form of carbonate of lime, such as chalk, shell-marl, or limestone, is available for the purpose, the latter being less employed on account of the cost of reducing it to powder. The great chalk-beds of England furnish an inexhaustible supply of excellent material for this purpose. In Germany large deposits of marl are utilized in cement-manufacture. This marl is a soft limestone, containing more or less clay, and is easily pulverized. In America the materials used hitherto have been limestone and shell-marl, the latter being a soft, fresh-water deposit similar to chalk. The only dangerous impurity likely to occur in any of these materials is magnesia, which, though harmless and probably advantageous in the manufacture of natural-rock cement, causes Portland

cement to crack to pieces after long periods if present to the amount of 4 per cent. or more. Clay, the other ingredient of the cement mixture, is to be found everywhere, and almost any clay will give fair results if free from sand or gravel. The best clays for the purpose are those which contain a high proportion of silica, since much iron and alumina make the clinker too fusible and are said to yield a cement which is less permanent, especially when acted on by sea-water.

The first essential in the manufacture of Portland cement is that the materials shall be perfectly mixed. For this purpose they must be very finely ground, as the presence of a very small percentage of coarse material in the mixture will give rise to most dangerous defects in the product. Neglect to produce a perfect mixture is the source of almost all failures in making good cement, and the materials or method of burning are often blamed for faults in the product which are due solely to imperfect preparation of the mixture. It is probable that the great excellence of certain brands of cement is due to the perfection of this part of the process, more than to all other causes put together. In England the chalk and clay are mixed in wash-mills, and the mixture washed through fine screens and allowed to settle in basins. This process is expensive, and has been gradually replaced in Germany and elsewhere by the dry process of mixing, in which the materials are dried, powdered, bolted, and ground together. After mixing, the cement-material is usually molded into bricks for burning and dried.

A second essential is a correct adjustment of the proportions of carbonate of lime and clay. Each kind of clay requires a definite proportion of lime to give the best results. Cements usually contain from 60 to 64 per cent. of lime, according to the composition of the clay. The correct proportion of lime once determined, it will be found that an increase of 1 per cent. will give a cement liable to crack to pieces, while a decrease of 1 per cent. from the normal amount will give a product deficient in strength. To keep the mixture uniform, in practice, requires the greatest watchfulness and the assistance of a capable chemist.

The burning of Portland cement is usually carried on in intermittent vertical kilns. These are charged with the bricks of material and coke in alternate layers until full; fire is lighted at the bottom and the charge allowed to burn out. The material is raised to a white heat, which slowly ascends to the top of the kiln. The filling, burning, and emptying of a kiln occupies about a week, and from 50 to 100 barrels of cement are obtained from a charge, according to the size of the kiln. After burning, the material is found in the form of "clinker," very hard and heavy, and of a greenish-black color. This is then crushed and ground to powder.

Within a few years continuous kilns have come largely into use for burning Portland cement. In these the fuel and material are charged together at the top, and the burned clinker periodically withdrawn at the bottom. These kilns save much labor, and yield a large output. The rapid destruction of the lining at the high heat employed and the adhesion of the clinker to the walls of the kiln are difficulties which have not yet been wholly overcome.

In the United States, the manufacture of Portland cement was begun at Coplay, Pennsylvania, in 1878. It is now carried on successfully at several points in Pennsylvania and Ohio and in the west, but the total output of American works does not supply more than one-eighth of the home demand for Portland cement, the balance being imported from England, Germany, and Belgium. Deposits of suitable material are not of frequent occurrence in the United States; the chalk-beds are located in the far west and south, at localities at present far removed from the chief markets; our limestones are chiefly highly magnesian and therefore unsuitable. Beds of shell-marl (or fresh-water chalk) of considerable extent are found at several points, however, and furnish the material at present chiefly used. The high price of labor, which makes up a large part of the cost of Portland cement, is doubtless a further reason for the slow development of the industry in this country.

We may now consider the chief uses to which cements are applied and the methods by which their quality may be tested. The process of manufacture is so simple that there appears to be every reason to expect a uniform and reliable product. We see constantly, however, cases in which work done with cement has utterly failed; sidewalks which have cracked and gone to pieces, floors which have expanded and pushed heavy walls out of line, and mortar which has weakened and finally fallen to dust after months or years. It is evident that there are hidden defects in some cements which may for a time escape notice, and that methods for the detection of these defects are absolutely necessary for protection against the failure of important work.

The chief qualities which make cement valuable are, perhaps, the following: setting and hardening properties, constancy of volume, permanence in water and in air, strength under tension and compression, resistance to wear, resistance to frost, impermeability by water, and adhesion to brick or stone. Let us now consider the chief uses to which cement is applied, and the special qualities which each use demands. It may be assumed that for all purposes rapid hardening properties and permanence in respect of strength and volume are essential.

I. Mortar and concrete: hardness, strength under compression.

II. Sidewalks and flooring: hardness, resistance to wear and frost.

III. Cistern, reservoir, and aqueduct linings: impermeability.

The testing of cements is a delicate operation, and much experience and judgment are necessary in order to secure even fairly accurate results. The methods of testing have been the subject of careful study by experts. In Germany, the requirements of the minister of public works* are recognized as a standard. In France, the requirements of the "Services Maritimes des Ponts et Chaussées" are generally followed.† In America, the subject of cement-testing has been carefully considered by a committee of the American Society of Civil Engineers, and their report ‡ will be found to contain full and valuable instructions. The German requirements are marked by simplicity, clearness, and good-sense, and probably represent the latest advances in the field of cement-testing.

We may now take up the chief qualities of cement which it is important to determine, the reasons for the failure of some cements to exhibit these qualities, and the methods by which such failure may be most surely and promptly recognized.

I. *Setting and hardening properties.* Cement, when mixed with water until plastic, gradually sets, becoming more or less hard and rigid. Natural-rock cement usually sets in a few minutes, or one-half hour at most. Portland cement requires a longer time, usually from two to eight hours. Cements containing a high proportion of clay, or those lightly burned, are more quick-setting than those high in lime or hard-burned. The time of setting is most easily determined by making a "pat" of the cement, about three inches in diameter and a half-inch thick, with thin edges, on a piece of glass about five inches square. The pat is placed in a tight box or under a damp cloth and tested from time to time, by light pressure with the finger nail, until no noticeable impression is made. The amount of water used greatly influences the time of setting, and different cements require different proportions of water to produce a given consistency. The German requirements prescribe the use of such an amount of water that several taps of the glass on the table or mixing-slab are required to make the pat spread out to the edges. The temperature of the room is also exceedingly important, as cement will set in a warm room in half the time, or less, required in a cold room. The room should be kept as nearly as possible at 70° F. during the mixing and setting, and the water used should be of this temperature. More accurate methods,

* These may be found in a very useful book, "Der Portland-Cement und seine Anwendungen in Bauwesen" (Berlin, 1893), published under the authority of the Association of German Cement Manufacturers.

† See Candlot, "Cements et Chaux Hydrauliques" (Berlin, 1887).

‡ Transactions, November, 1885.

using a needle 1-24 of an inch in diameter, carrying a weight of one pound, are also employed, but are unnecessary for practical purposes.

After remaining twenty-four hours in moist air, or at least over night, the pat is placed in water (kept at 70° F.), and the progress of the hardening noted. Good cement should harden rapidly and after one day in water should appear perfectly hardened, so that it cannot be scratched or scraped away by the finger nail. Good Portland cements are slow-setting and quick-hardening. There are many inferior cements which remain soft for several days, though they may become quite hard in time. The best cements are those which gain great hardness within a few days and show no falling off at long periods.

II. *Constancy of volume and permanence.* The question of the soundness and lasting-qualities of cement is perhaps of greater consequence than any other, as the stability of work done with it depends entirely upon this quality. Some cements, though hardening well when first used, show after weeks or months a tendency to swell or crack, often lifting great masses of masonry by their expansion, and after a longer time are found to have fallen completely to powder. The cause of this alarming defect is the presence of free or imperfectly combined lime in the cement, due to too high a proportion of lime in the raw material, or more often to imperfect mixing of the ingredients. The presence of a small percentage of coarse particles of carbonate of lime in the mixture will infallibly produce an unsound cement. This fault is exceedingly liable to occur, since the perfect grinding and mixing of the raw materials are a matter of great difficulty and expense. Free lime in cements slakes only after long periods, and in slaking expands and causes the hardened cement to crack to pieces. The presence of more than 4 per cent. of magnesia in Portland cement is supposed to produce the same effect. So far as is known, the presence of free lime (or magnesia) in cement is the sole cause of its failure to maintain the strength and hardness at first acquired. As this fault is always the result of expansion, it may be said that cements of constant volume will prove permanent in use.

The usual method of recognizing a tendency to expand or crack is the pat test already described. Two such pats should be made and allowed to set; one is then placed in water and the other kept in moist air. The first evidence of bad quality is the loosening of the pat from the glass, which generally takes place, if at all, within one or two days. Bad cement will also show fine radical cracks on the thin edges of the pat, which will also curve up more or less at the edges, presenting a saucer-like shape, and will often become covered

with a net-work of cracks, like alligator-leather. These appearances are usually more marked in the pat kept in moist air. Good cement will remain firmly attached to the glass for two weeks at least, will harden well within two or three days, and will show no cracks, even after a month or more in water. Among the many tests which may be applied to cement, there is none which gives so sure and complete an indication of its quality as this simple pat test on glass; time of setting, hardening qualities, and permanence are thus determined in a single operation.

The hot test, for the quick detection of any tendency to expand or crack, has come into extensive use within the past few years, and has proved to be of great value.* The test consists in exposing a pat of cement, prepared on glass as described above, to the action of steam for about three hours; then allowing it to lie in boiling water for an equal time. The presence of a very small proportion of free lime will cause the pat to swell and crack under this treatment, and sometimes to fall completely to powder, while perfectly sound cements will remain on the glass and harden well, showing no sign of cracking. The Association of German Cement-makers has refused to endorse this test, claiming that it is too severe, and that its use would condemn many cements which prove perfectly sound in practice. There is, however, a very close connection between cracking under the hot test and failure of the cement after long periods, and there can be no doubt that both result from the presence of free lime, chiefly due to imperfect mixture of the materials. It is certain, also, that proper care in manufacture will produce cement which will stand the hot test perfectly, even when very fresh. The use of the hot test is a great safeguard to consumers, as a cement which stands this test well may be relied upon to prove perfectly sound and permanent for all uses, in water as well as in air.

After prolonged seasoning or exposure to air, most cements which show a tendency to crack when fresh will be greatly improved, and may become perfectly sound, owing to the gradual slaking of the free lime present. It is not well, however, to rely too much on this method of cure, as the final destruction of the work is often only postponed by this process. Such seasoned cement will rarely stand the hot test and becomes more dangerous, owing to the fact that its unsoundness may escape detection by the cold pat tests usually employed.

III. *Strength under tension and compression.* Tensile strength is determined by making up briquets of the cement, both neat and with sand, and pulling them apart on a testing-machine after a certain period in water. In Germany the only test officially recognized is that of

* Full directions for making this test have been given by Captain W. W. Maclay, Transactions of the American Society of Civil Engineers, 1892.

cement with three parts of sand, broken at twenty-eight days. In this country neat tests at shorter periods are also generally made. The results of these tests depend to a surprising degree on the conditions under which the briquets are made, and no one can hope to obtain uniform or just results without practice and careful observation of many minute precautions.

The temperature of the room in which the briquets are made, and also that of the water used for mixing and that in which the briquets are allowed to lie, should be kept as nearly as possible at 70° F. The effect of this is seen especially in the results at short periods. A sample of cement which shows a strength of 150 pounds after twenty-four hours, when the briquets are made and allowed to set in a warm room, will generally show less than 50 pounds if kept in a room near the freezing-point.

The amount of water used should be such as to produce a uniformly plastic mortar. Different cements require different amounts of water; for quick-setting natural-rock cement at least 30 per cent. of water will be necessary, while with Portland cement from 22 to 25 per cent. will be found sufficient. The use of more water than is necessary to produce a fairly plastic mortar greatly weakens the briquets.

The manner of mixing the mortar greatly affects the results, as the longer the mixture is worked with the trowel, up to a certain point, the greater strength the briquets will show. The cement and water should be mixed on a slab of slate or marble, and worked thoroughly with a trowel for at least five minutes. A good plan is to rub enough mixture for each briquet in a large porcelain mortar for a few moments. If this practice is adopted it should be uniformly adhered to.

The molds should be slightly oiled (or soaped) on the inside. The mortar is then pressed into them as firmly as possible with the thumbs, rubber thumb-caps being used to protect the hands. The consistency of the mortar should be such that a firm pressure can be used. Pounding the mortar into the molds will give higher breaks, especially if only 18 to 20 per cent. of water be used, but is not to be recommended, as uniform results cannot be obtained by this method. The surface is smoothed off with the trowel, and should appear wet and plastic. The molds are then turned over, filled, and smoothed off on the other side. The briquets are then placed under a damp cloth and left until set before the molds are removed. With quick-setting cement two hours will be sufficient; with Portland cement the molds should not be removed until the next day. In all cases the briquets should be left for twenty-four hours in air before placing in water.

Sand tests are usually made with one, two, or three parts, by weight, of sand. With three parts of sand, water to the amount of 10 per cent.

of the total weight of cement and sand will be found to give the best results, and this proportion is specified in the German requirements. The character of the sand used greatly affects the results. In Germany a natural sand from Freienwalde o Oder, passing a sieve of 20 meshes to the inch and remaining on one of 30 meshes, is recognized as the standard. In the United States, crushed quartz of the above fineness is generally used, as recommended by the Society of Civil Engineers. This is made by several manufacturers of sandpaper. Ordinary building-sand will generally be found to give rather higher results than the standard sand, as the varying size of the grains leaves less space to be filled with cement. In making sand briquets, thoroughness of mixing is even more essential than in neat tests. The German requirements specify that the mixture of cement, sand, and water shall be strongly worked for five minutes. The writer lately tested a cement with three parts sand and found that, after working the mixture one minute, a tensile strength of 87 pounds in seven days was obtained, while the same mixture, strongly worked for five minutes, gave a strength of 240 pounds in the same time.

In making sand briquets a certain amount of pounding is necessary. The German requirements recommend the use of an iron spatula weighing 250 grams. Uniform results may generally be obtained by filling the molds above the top, laying on a piece of wood, and gently pounding with a hammer or mallet. In actual work the proportions of cement and sand are always measured (usually by shovelfuls), not weighed. As cement is 50 per cent. heavier than sand, allowance must be made for this in estimating the value of various mixtures for practical purposes. One part of sand by weight is equal to 1½ parts by measure. Briquets of 1 cement to 3 sand therefore represent the strength which may be obtained in practice from mixtures of 1 cement to 4½ sand, by measure.

In judging the results of tests of tensile strength it should be remembered that steadily increasing strength at long periods is better proof of good quality than high results during the first few days. The behavior of the cement in the pat test and hot test should also be considered in this connection. Cements which are very high in lime, and even those showing a slight tendency to expand and crack, often show astonishingly high breaks at one day and at seven days. This appears to be due to a condition of strain, and is nearly always followed by falling off in strength when tested at twenty-eight days and longer periods.

Natural-rock cement, neat, will generally show 50 to 75 pounds in seven days, and 100 to 200 pounds in twenty-eight days. Good Portland cement, neat, will show from 100 to 200 pounds in one day, 400

to 600 pounds in seven days, and 600 to 800 pounds in twenty-eight days. With three parts sand, Portland cement should give at least 100 pounds in seven days, and 200 pounds in twenty-eight days. The German requirements specify that cement with three parts sand shall show a strength at twenty-eight days of 16 kilograms per square centimeter, corresponding to 227 pounds per square inch.

Compression tests are rarely made in America, owing to the rather costly apparatus required. Such tests are, however, of great value in determining the suitability of cement for important work. In general it has been found that the results of compression tests, both neat and with sand, are about ten times as high as tensile tests on the same section. Natural-rock cements give generally relatively lower results in compression tests.

IV. *Resistance to wear, impermeability, etc.* The tests for time of setting, constancy of volume, and strength under tension and compression are the only ones generally made, since these qualities vary greatly, even in different samples of cement of the same make. The other essential qualities of good cement, such as resistance to wear, resistance to frost, impermeability by water, and adhesion to brick or stone, are not liable to great variations, and it may be assumed that any cement which stands the usual tests will give satisfactory results in all other respects.

Tests of the comparative power of different cements and mixtures of cement with sand to resist wear have been made by Professor Böhme, head of the royal testing-station for building materials in Berlin. His apparatus consists of a rotating cast-iron table sprinkled with emery powder, upon which cubes of cement are ground for a given time under constant pressure. Neat cement is found to be greatly inferior in wearing qualities to mixtures of cement with sand, being, in fact, about equal to a mixture of 1 to $3\frac{1}{2}$ parts. The best wearing qualities are shown by a mixture of 1 part cement to 1 part sand (by weight); practically equal results are obtained with a mixture of 1 : 2. These facts have an important bearing on the use of cement for sidewalks and flooring. The greatest fault met with in sidewalk work is the occurrence of long irregular cracks across the blocks. This fault is usually attributed to the poor quality of the cement or to frost, but it is solely due to slight shrinkage of the cement in hardening, and occurs with the best and hardest cements when the proportion of sand employed is too small.

As for resistance to frost, little or no hardening takes place at temperatures below freezing, and partially hardened cement, saturated with water, is liable to suffer much in strength by being frozen. After thawing, however, the hardening proceeds again, and in most cases no

serious results from freezing are apparent. The addition of salt to the mortar, often practiced, is harmless, and in some cases may be of value. The chief point to be observed in using cement in winter is the sparing addition of water. In fact, an excess of water is in all cases injurious, as the strength of the work is greatly weakened by it. Probably in nine cases out of ten masons add far more water than they should, from either carelessness or a desire to avoid the greater labor of working less fluid mortar. The best results are always obtained by making a mixture of cement and sand not wetter than moist garden earth. No water should be visible until the mixture is well trowelled or pounded. If this precaution be observed, cement work may be carried on in the coldest weather without bad results.

V. *Impermeability.* Cement is extensively used as a waterproof material, especially in lining cisterns, aqueducts, and reservoirs. The impermeability of cement-mortar increases greatly with age, so that comparatively porous mixtures will become quite dense in time. For linings which are to be immediately waterproof not more than one part of sand (by weight) to one of cement can safely be used. A mixture of 1 cement to 2 sand will, however, prove impermeable after the lapse of a few weeks. The addition of slaked lime to the mortar greatly increases its density, and also increases the strength of mixtures poor in cement. In concrete work a mixture of 1 part of lime, previously well slaked, 1 part Portland cement, and 6 parts sand will be found to give as good results as 2 parts cement to 6 of sand, the lime thus replacing half the cement without causing loss of strength. Used in this manner Portland cement will be found much cheaper than the natural-rock cements for ordinary uses. For waterproof linings a mixture of 1 part cement, ½ part slaked lime, and 3 parts sand, or even 1 cement, 1 slaked lime, and 6 sand, will be found sufficiently impermeable. It has also been found that the addition of slaked lime to cement-mortar greatly increases its adhesion to brick or stone. Masons often object to using mixtures of cement with three or more parts sand as mortar for brickwork and masonry, on account of its working "short" under the trowel. Increasing the proportion of cement is extravagant and unnecessary. The objection can be overcome by adding one part of slaked lime, which will make the mortar "fat," plastic, and easy to work.

THE PINE INDUSTRY IN THE SOUTH.

By George L. Fowler.

THE lumber industry in the southern United States, ranking in importance with that of the states of the north, possesses some features which distinguish it from the methods of preparing lumber for market elsewhere. The readers of this Magazine who followed Mr. Parker in his account of "The Northern White Pine Industry" last month may be interested in a presentation of some facts relative to the longleaf yellow pine, known also as the Georgia pine, which is widely regarded as the most desirable wood in the market for a great variety of purposes.

The size to which this tree grows enables the sawyer to cut sticks of almost any desired size or length, and large quantities of the wood are consumed in the manufacture of car-sills and bridge timbers, while the smaller sizes furnish a favorite class of wainscoting, flooring, and ceiling. Strange as it may seem, there are no trustworthy statistics of the amount of this timber standing or in sight, or even of the annual output. Various estimates have appeared, but those who are best informed agree that not even an approximation has ever been made. This is due to the fact that there is no lumber exchange in the south charged with the collection and verification of such statistics, and that there are a great number of small sawmills of whose output absolutely no record is kept. Perhaps as near an approximation as can be made is that of 400,000,000 feet per annum of the Georgia pine.

Very little rafting of logs is done in the south, so that there are no large boom companies handling lumber, with records that would serve as a basis for approximate statistics. The pine grows on high sandy soil, away from the streams. Although the trees stand comparatively near together, the large or "saw" trees are so few and far between that it requires careful selection to get more than 8000 feet of lumber to the acre, while the probable average is nearer 5000 feet. The foliage is scant and the sun streams through as in an open grove, and the ground is covered by a thick growth of rank wire-grass which serves as the sole means of subsistence for thousands of cattle and hogs that roam through the woods, with even less attention than that bestowed upon the herds on the western prairies.

The first step taken in the manufacture of Georgia pine lumber is to turn over a block of the trees to the proprietor of a turpentine distillery. He "boxes" and "scales" the trees. That is, he cuts in one side of the tree a "box" which will hold about a quart of sap, and

then slashes away the bark to a height of four or five feet, running up to a V at the top. The resinous exudations from the sappy portions of the wood run down into the box and are thence gathered for distillation into turpentine and resin. The trees are usually allowed to remain in this condition for three years, the product of the first year being the most valuable. Lumbermen do not regard this process as injurious to the tree in any way, either to its subsequent life or to the value of the lumber to be cut from the trunk. So the process goes on; the trees stand for three years bearing their own tombstones and, indeed, presenting a very strong likeness to a graveyard in a grove.

At the end of the three years of "turpentining," the axemen go into the woods and the more rapid work of destruction begins. Cutting is continued throughout the year, as the season during which the trees are cut makes little or no difference in the quality of the lumber. This work is done usually with the axe, as there are few woodsmen in the south who use the saw for felling trees. After the tree is upon the ground, nothing is done in the woods save to lop off the branches and cut off the top. The cutting of the trunks to suitable lengths is usually done at the mill, where logs are selected to fill certain "bills." The peculiarity of the Georgia sawmill is that most of its orders are for "bill" stuff, which may vary from twelve feet to sixty feet in length, and that very little is cut into boards and standard sizes. When the trunk is down the teamster is on hand with a four- or six-horse team of mules and a pair of heavy wheels, averaging about seven feet in diameter, with tires seven or more inches wide. A heavy pair of grip-tongs hangs from the axle in such a way that they may be lowered and opened by raising the tongue. As the tongue is brought down, the tongs grip the log in the middle of its length and raise it from the ground. Strong chains then secure the tongue to the log, the team is hitched on, and the log is started toward the mill.

The ease and certainty with which the negro drivers handle their teams is an interesting feature of this woodland work. Amid a shrieking, yelling lot of teamsters, creating a bedlam, each mule seems to know his own driver's voice and will stand stock still until ordered by him to move. When hauling, the driver rides the near wheel mule and his three methods of control are the loud cracking blacksnake whip, his voice, and the single rein leading to the bit of the near leader. A steady pull on this rein will turn the team to the left and a series of jerks will send it to the right. With this alone, and without any holdback or brake other than the light trailing of the rear end of the stick, the load is taken up and down hill, worming its way between trees and stumps, rarely hitting anything, and is finally deposited exactly where it is wanted, either at the mill or at the runway beside the logging-road

built out into the woods. On the return for the load, no pains is taken to avoid any obstruction, and the mules and cart are driven over logs and stumps with a surprising abandon.

The smaller concerns, whose capital and output are limited, haul the logs directly to the mill, while the larger mill-owners have built logging railroads for many miles into the woods. The construction of these logging-roads is of a superior character. The hills rarely present very steep grades, so that the ties are laid practically upon the natural surface of the ground, which gives a roadway full of sags and crests, necessitating careful work on the part of the locomotive engineer to avoid breaking in two. The cars used are low, flat cars, from thirty to thirty-four feet long, mounted on bogie trucks and coupled with a link thirty-five feet long. This link is made of a stick about eight inches in diameter and shod at either end with an eye for the link-pin. In this way logs of eighty or even ninety feet in length can be carried very easily on a single car. They are loaded in a single row across the platform and are rarely heaped up.

In describing the southern sawmill, it seems best to take one equipped with the best and most approved machinery and doing business upon a large scale, rather than the smaller mills where the output is meager and the plant of an antiquated pattern. These small mills are scattered throughout the southern part of Georgia and are worked with forty-inch saws and a rack or friction feed at a speed but little superior to the vertical saw of early days. They eke out a precarious livelihood for their owners, principally because business methods are as lacking as improved machinery, and the owners of such mills stand, by the score, on the verge of bankruptcy. Of the forty-seven operating sawmills reported along the line of the Georgia Southern and Florida railroad the daily capacity ranges from 5000 to 80,000 feet of lumber per day, the average being about 16,000 feet, and these figures may be taken as the average for the remaining mills of this section, of which there are an unknown number. While the facts presented in this paper relate especially to the lumber industry as conducted in Georgia, it may be added that the same conditions prevail in portions of the neighboring states of North Carolina, South Carolina and Alabama, in which sections of the pine area are also to be found.

The logs reach one of the better class of mills on the cars and are rolled off upon the skidway in about fifteen minutes by men with cant-hooks, working in gangs of three or four. On the skidway they are sawed into proper lengths by hand power, and thence loaded upon a heavy car which is hauled up the inclined log-run into the mill. The machinery is usually in the second story, which gives ample room for the engines, shafting, sawdust-conveyors, and belting beneath the

A TYPICAL GEORGIAN PINE-FOREST, BEFORE CUTTING HAS BEGUN.

floor. The engine used for driving the saw is usually of the plain slide or roller-valve type, with no pretense of close adjustment for speed or economical use of steam, for the economical use of the steam is the last thing that the mill superintendent seeks to accomplish. He cannot even burn all his sawdust under the boilers, to say nothing of slabs and edgings. The boilers are of the return multitubular type and are run with the safety-valves blowing, and supply steam for the 100 to 150 horse-power engine which drives the main circular saw.

This saw is *the* saw of the mill and cuts everything from the heavy bridge timber to the one-inch board. It is usually sixty inches in diameter and is run at a speed of 800 revolutions per minute. It is belted direct to the main engine and can only be stopped by stopping the engine. The teeth of the saw are swaged out to cut a kerf of five-sixteenths of an inch.

The log-carriage, which is entirely independent of the saw, runs on a truncated, inverted V-shaped track and is carried on wheels about ten inches in diameter. There is a single headblock at one end, operated by a man who rides on the carriage, and has a reciprocating motion given to it by a pair of engines with cylinders nine inches in diameter and sixteen inches stroke, coupled on the quarter and driving a grooved rope drum. As the engines are reversible it is evident that, by passing the rope around pulleys outside the carriage travel, the latter can be pulled up in either direction. The advancing or "feed" speed of this carriage is made to vary according to the size of the log being cut, and ranges from three to eight inches per revolution of the saw. This corresponds roughly to a cut of from 300 to 800 feet per minute. One who has not seen one of these mills in operation can have no realization of the rapidity with which the work is done. A log twenty feet long will have a slab or board taken off in about the same length of time that the wood-sawyer will cut off a four- or five-inch stick with a horse treadmill as a motive power. On the return the speed of the carriage may be said to average about 1500 feet per minute. The circular is then *the* saw of the mill. Gang-saws are not used because they are adapted only for the economical sawing of boards, and cannot be used to any advantage on orders calling for a miscellaneous assortment of special sizes.

Square timber, joists, scantlings, and ordinary "bill" stuff leave the circular saw ready for shipment, but boards are subjected to further treatment. The slabs, when they fall from the log, are thrown upon a conveyor by which they are carried to a saw that cuts them into suitable lengths for being manufactured into lath, or they are carried away and dumped from a high trestle into a pit, where they are burned at the rate of millions of feet every year. Such a trestle may be seen

BANKING GROUND IN A GEORGIAN PINE FOREST, ALONGSIDE THE LOGGING-TRACK.

near the right of our view of the mill at Richwood, Georgia, shown on the opposite page.

The boards are thrown, as they are cut, upon "live" rollers,—*i. e.*, rollers that are kept in motion,—and carried along to the edger. Sometimes, however, boards are cut from logs forty or fifty feet long, so that when anything comes along that is more than eighteen or twenty feet in length, the man in charge stops the rolls when the board reaches the proper point and raises a "jump" saw through the board, cutting it into suitable lengths for handling. This "jump" saw is constantly in motion and is raised by a steam-cylinder whose piston-rod is attached directly to the boxes carrying the saw arbor. The pressure of the foot upon a lever admits steam to the bottom of the cylinder and the piston is raised. The removal of the foot opens the valve, the steam is exhausted, and the saw drops out of sight.

The "edger" is merely a saw-table with two saws, one stationary and the other movable. It is used to cut off the bark that may have been left upon the board by the circular saw. The object of the movable saw is to cut boards of varying widths without wasting the lumber.

From the edger the board passes to the "trimmer," which trims off the ends of the board square with the edges and leaves it the standard length, say twelve or twenty feet. When the board leaves the trimmer the work of the sawmill proper is done, and the lumber is ready for the dry-house or for shipment. If the mill skidway were empty and everything in readiness, the average working would carry a log twenty feet long and twenty inches in diameter up the incline, put it on the saw carriage, cut it up into say 2 × 4″ bill stuff, edge and trim the boards, and clear the mill of its presence in about ten minutes.

The natural auxiliaries of the sawmill are the planing-, lath-, and shingle-mills. The first is a mere duplicate of what may be found in every town. There are "surfacers" for smoothing the sides of the board, matchers for tongueing and grooving, and saws. There is nothing about them peculiar to the Georgia lumber industry except that occasionally a mill is found with a planer for dressing large square timbers. The lath- and shingle-mill can be operated to advantage only in direct connection with the sawmill, whose waste they serve to put into useful shape. A lath-mill consists of a cut-off saw for cutting the slabs to the proper length; a rip-saw for sawing these lengths into thicknesses the width of the lath; a gang-rip-saw for cutting the lath; and a bunching-machine for shaping and holding the bunches while they are being tied with marline. Four men and three boys serve to do the work, and they will make from 25,000 to 35,000 lath per day, according to the size of the slabs.

The shingle-mill uses the waste in the shape of the butt ends of logs,

MAIN SAWMILL OF THE RICHWOOD (GEORGIA) LUMBER COMPANY.

or ends sawed off from the square timber, and its machinery consists of a cut-off saw, a rip-saw, a shingle-saw and two bunchers, with a conveyor from the shingle-saw to the bunching-table. Shingle-saws are made with from one to ten "blocks"; that is, they cut from one to ten shingles with each complete stroke of the saw, but the capacity does not increase with the number of blocks. Two-block machines are deservedly very popular on account of the simplicity of their construction and their easy action. They will cut about 35,000 shingles in ten hours.

We have now followed the wood from the tree to the market, and by far too small a percentage reaches this latter point. Waste is everywhere apparent, and even the most careful managers acknowledge that their wastefulness is extreme. High railroad freights and long distance from markets render it unprofitable in the south to engage in the manufacture of many small articles that might readily be made from slabs and edgings. But there is another source of waste for which absolutely no excuse exists, due to slack business methods and ignorance of the capacity and capability of modern wood-working machinery. There is extravagance in the thickness of the lumber used for certain purposes. For example, what is known as a bevel-edge weather-board is one-half inch thick on one edge, one-quarter on the other, and six inches wide. The rough stuff ordinarily furnished for this is six inches wide and 1¼ inches thick. This allows for re-sawing and finishing two surfaces. The allowance is one-quarter inch for the kerf of the saw, and one-eighth of an inch for each smoothing finish, whereas one inch in thickness is ample, allowing one-eighth of an inch for the kerf, while three sixty-fourths should be enough for finishing. This would leave the rough stuff with a total thickness of less than an inch and effect a saving of over 20 per cent. Mill-owners of the first grade are ready to acknowledge this wastefulness and point it out, but it seems to be inbred in the bone and very little is done to check it.

No description of the Georgia pine industry would be complete without a reference to the labor element. It has been customary for outsiders to consider the southern laborer as slow, lazy, and shiftless, but no stranger could enter one of these mills or pass a day in the woods without being surprised and charmed by the vigor and rush with which the work is performed. The carriages fly with the speed of express trains, and the sharp tang of the saw is unceasing; or, if you are in the woods, the cries and shouts of the drivers and cutters ring upon the ears in an unending chorus. The very animals seem infected with the rush and the drive, and the liveliest western community under the influence of the most powerful of "booms" could not be more active or wide-awake. Work has become an instinct; the laborer knows but

Convict sentry-boxes in background.
Slab-conveyor to burning-pit.
Dry-house.
Storehouses.
Tanks for feeding boilers
Logging-road.

ANOTHER VIEW OF THE RICHWOOD LUMBER COMPANY'S SAWMILL.

GANG OF CONVICTS AT A GEORGIA SAWMILL PREPARING FOR WORK.

[Wrapping about their ankles the chains with which they were fastened together while being brought from the camp to the mill-ground.]

four conditions,—eating, sleeping, working, and, after pay-day, a carouse or absolute idleness. Negro labor, which is the sole dependence, is better, more reliable, and therefore cheaper than the white, but, as the laborer has no mental resources, and as he is cut off from the pleasures of his city brethren, his discontent is quickly manifested when the hours of idleness are upon him.

A curious story of a strike is told at one of the mills. The hours of labor are long,—from dawn to twilight. In the winter the hours are fewer, but in summer the saws are buzzing and the whole community alive and at work before the sun has touched the tree-tops. A northern foreman of philanthropic principles took charge of a certain mill, and sorrowed within his heart for the poor fellows wearing out their lives with the cant-hook and saw. So he decreed that from 7 A. M. to 6 P. M. should constitute the labor of a day. There was a murmur in the camp and in two days there was a general strike. Called upon for reasons, the spokesman stated the case of the men: "We all jus' doan like dis yar gwine ter wuk at seben o'clock. Wha's de use ob sittin aroun' fer two hours in the mawnin' fo' gwine ter wuk? We jus' ain' gwine to stan' it, dat's all." So the strike was declared off by the superintendent agreeing to allow all hands to go to work at dawn and keep at it as long as they could see.

Convict labor cuts a prominent figure in Georgia. The convicts are "farmed out" by the state to mill-owners and work side by side with the free hands. Of abuses there are undoubtedly many, but when one compares the comfortable quarters of the convicts, their healthy, palatable food, the care given to them in sickness, and the *tout ensemble* of their surroundings, with the barren quarters, scanty food, and hardships of the free laborers, one is tempted almost to cast his lot with the convicts. The negro laborer is a child in his improvidence and helplessness; he spends his wages before he earns them and is always poor. I walked one day from a convict-camp, where the men were well housed and fed, to the free quarters, where squalor and poverty were so apparent as to be heartrending. I saw one man and his wife living in a house in which there was absolutely no furniture. Their meat was roasted on a spit and their vegetables cooked in the ashes. When they went out they carried all of their earthly belongings with them. But the climate is so warm and the air so pure and fragrant that of actual suffering they seem to have but little.

The convicts are treated differently. To quote a mill-superintendent: "We look upon them as animals bought to do a certain amount of work, and for which we pay hard cash. If they are sick we are responsible, and the pay goes on; therefore, in pure self interest, we feed them well, not luxuriously, but healthfully and in abundance; we

house them well and keep them clean, and our hospital is rarely occupied." There is no maltreatment; it is a criminal offence for any but the captain to strike a convict, and this is a duty he cannot delegate to another. To be sure, obstreperousness is punished with the lash, but good conduct receives its reward and the "trusties" have a freedom that is so great as to do away with the stings of imprisonment. The men wear an anklet with a chain attached, but it is wrapped out of sight, and their movements are not impeded by it. A guard of white men is picketed about the mill-grounds, and the sharp crack of a Winchester and the ping of a bullet would follow any attempt to break the cordon.

In the earlier days the differences existing between the mills of Michigan and the mills of Georgia were very great, but the progressive machinery builders have made their influence so widely felt that engines, saws, planers, and mills might be exchanged in a night and the workmen fail to notice a difference in the morning. The variations are due to the class of work. The gang-saw, for example, has no foothold in Georgia because it is not adapted to "bill stuff," while every large mill in Michigan depends upon its gang-saw for boards. Timber is getting less plentiful in Michigan; the five-sixteenths kerf of the circular is wasteful and the slower cutting band-saw with a kerf of three-sixteenths is taking its place. But aside from this, the planning of the mills, the arrangement of engines, saws, and conveyors is in one section the counterpart of that in the other.

THE SCIENCE OF ELECTROMETALLURGY.

By Alfred E. Hunt, S. B.

TO an Englishman, Mr. C. C. Jordan, belongs the honor of first making known, in 1839, a process for producing metallic copies of any surface by the electrodeposition of metals. Professor Jacobi, of St. Petersburg, Russia, followed very soon after with the same idea. Dr. Golding Bird and Mr. Henry Dicks, in 1837, did much valuable pioneer work upon the art of electrotyping. Sir Henry Bessemer writes of his own work in this art, in the years 1831-32, as follows: "The first conception of the idea of coating works of art in metal with a deposited coating of another metal, if not resting solely with me, was practiced successfully three or four years under my direction before it was brought out by Jordan."

The famous physicist, Sir Humphry Davy, "Father of Electrometallurgy," intelligently described in 1810 the work of electrolysis and the success which he obtained by this method of separating sodium and potassium, and perhaps aluminum and other metals, from their chemical combinations. The methods of electrotyping have been greatly improved since their origin, and much of this development has been due to American ingenuity and skill.

In electrotyping or electroplating, the type, metal, or other object to be plated is placed in a solution of a salt of the metal in connection with the negative pole or cathode of an electric-generator forming the anode, the salt is decomposed by the current, and the metallic element is deposited on the negative pole in connection with the suspended object to be coated, forming the cathode. A piece of the metal is usually attached to the anode or positive pole in the solution, and, by being attacked by the acid formed at the anode, is dissolved, re-forming the salt and regenerating or keeping up the strength of the solution or electrolyte.

A reversed mold or hollow cast of the object to be electrotyped is first obtained, and upon this copper or the other coating metal to be used is electrolytically deposited to a required thickness in this negative impression of the object. Graphite is used as a coating or film for the molds, to produce a conducting surface for the electric current and to facilitate the removal of the deposit when completed.

In electroplating with gold or silver, the object is first cleaned by various processes to remove all oil, dirt, oxid, or other films from their surfaces, so that firmly adhering coatings can be secured. A better-adhering coating can be obtained on copper surfaces than on any other,

and many processes of plating include a preliminary coating of copper and then a deposition of other metals upon this coating. The double cyanide of silver and potassium in a liquid containing an excess of potassium cyanide is the salt generally used for a silver-plating bath, although many other silver salts are used for the same purpose.

The physical structure of electrodeposited metals is much affected by the density of the current at the cathode,—the weaker the current the more crystalline the deposited metal. If moderately strong, the deposit will be reguline ; and if the current be very strong, the metal will separate of course in larger quantities but in a soft powder, usually black in color, and in an extremely fine state of subdivision.

As with silver, the double cyanide solutions have proved best for gold-plating, but many other salts are used to avoid the use of poisonous cyanides. The color and appearance of gold-plating is altered very considerably by the strength of the current used ; too strong a current will give a black non-adherent coating, and the stronger the current the deeper the yellow color of the deposited gold.

Nickel-plating has become of importance since the cheapening of pure nickel to the present price (about 45 cents per pound). The double sulphate of nickel and ammonia is the most-commonly-used salt of the metal, although, as in the cases of copper,- gold,- and silver-plating, very many solutions of different salts of the metal have been used, each with its advantages under varying conditions.

The electricdeposition of cobalt, platinum, iridium, cadmium, antimony, and bismuth has been worked out upon a practical scale, and is more or less useful, as the peculiar advantages of coatings of these various metals are desirable for certain purposes. The electrodeposition of iron upon the surface of engraved copper plates has been advantageously used in order that the printer may obtain a greater number of impressions from the same plate, due to the increased hardness of the iron over copper. Both tin and zinc are more satisfactorily and economically deposited on iron by dipping the iron into a bath of the molten metal than by electrolysis, though both tin and zinc can be electrodeposited readily.

The electrodeposition of alloys has been practiced upon a commercial scale in the plating of brass, of bronze, and of German silver. The same general principles are employed in the plating of alloys.

The plating of some of the metals with gold, silver, and nickel has proved a difficult task. In most such cases, the object to be plated is first coated with copper by either immersion or electrodeposition ; and then upon the copper surface the finally desired coating is plated. This expedient has been adopted in the plating of aluminum with success, although another method has lately been devised which is superior.

This latter method consists in first dipping the aluminum into a solution of caustic soda or potash, then dipping into hot dilute nitric acid, then into hot water, then into a solution of corrosive sublimate, then again into the caustic alkali solution, and then into hot water, and finally into a solution of the salt of the desired coating metal, where, by electrodeposition, the final deposit is made.

Electrolysis, or the process of decomposing a chemical compound by the passage of an electric current through it, has lately been successfully used as a means of separation of the metals more difficult to decompose and keep isolated. That this art will soon be carried out on a much larger scale the writer is confident.

By employing mercury cathodes some of the most highly oxidizable metals can be separated, such as chromium, manganese, etc., in the form of amalgams, the mercury absorbing the deposited metal and largely protecting it from oxidation. All that remains to be done in the most of such cases is to distill off the mercury at a low temperature in an inert atmosphere to obtain the metals pure. Electrolysis has been already applied successfully upon a large commercial scale to the refining of copper, silver, and gold.

The principle of the refining process consists in the fact that the electric current does not cause the solution of all of the component parts of the crude metal at the same time, but makes a selection. By taking advantage of this a separation of complex substances is often possible.

In the electrolytic refining of copper, a nearly saturated solution of sulphate of copper is used as an electrolyte. Many tanks are used, placed in series by electrical connections. In this way each tank takes the entire intensity of the current. The impure copper to be refined, as it comes from the smelting-furnaces, is cast into slabs or plates, which are used as anodes, pure thin sheets of copper being used as cathodes. The refining operation goes on until the sulphate-of-copper solution becomes so highly charged with sulphate of iron and other impurities as to necessarily stop carrying on the operation. The residue from the refining operation settles in the bottom of the vats in the form of "mud," and often contains the precious metals in quantities sufficient for smelting.

The rate of deposition of copper is usually from five to ten ounces per twenty-four hours per square foot of cathode surface exposed. Ten amperes of current per square foot are usually employed, unless the large content of bismuth, antimony, or arsenic requires as lower speed of deposition to insure purity. At the large electrolytic copper plants in America the rate of deposition is from 3¼ to four pounds of copper per electrical horse-power-hour.

In the refining of silver, nitric acid of about 36° B. is the solvent. The process is based upon the selective power of nitric acid by which the silver is dissolved and reprecipitated with less electromotive force than the usually accompanying metals, bismuth, lead, and gold. At the works of the Pennsylvania Lead Company a current of 180 amperes is used, with an electromotive force of 1⅓ volts for each pot or compartment, of which there are seventy connected in series in each circuit. Each compartment has three anodes of the silver to be refined, 10 × 20 × ½ inches, and four cathodes of about the same area of thin sheets of pure silver. The anodes are hung in bags to catch the valuable impurities which drop from them in their corrosion. About two pounds of nitric acid per compartment is used in the process per twenty-four hours. The amount of silver deposited is about 470 ounces per twenty-four hours per compartment, or 4.2 pounds avoirdupois per hour per electric horse-power, with a plant producing about a ton of silver per day of twenty-four hours.

Gold is similarly refined from a nitric-acid solution by electrolysis, the metal being first dissolved in *aqua regia* and the excess of hydrochloric acid driven off by evaporation. Aluminum, magnesium, sodium, and potassium are the only metals which are now separated from their ores or salts by electrodeposition on a commercially successful scale.

Aluminum belongs to a class of metals whose oxids are not decomposed by intimate contact with hot solid carbon at any temperature short of the highest heat of a regenerative open-hearth furnace or of the electric arc. Alumina is not only not reduced by hot solid carbon or any other cheap reducing-agent, but it is difficult to reduce in a pure condition by any other process for the reason that any conditions which will reduce the metal are sure to reduce any other metals whose salts may be present with those of the aluminum; thus necessitating the expense of practically chemically-pure reagents and aluminum ores. Again, as the metal has such a small specific gravity, it is difficult to separate from the many varying substances whose specific gravity is about the same, and if separated at the top of the bath, it occasions not only loss by oxidation, but short-circuiting of the pot as well. To add to these difficulties, if heated much above its melting-point (1160° F.) aluminum has the mischievous property of occluding gases with which it may come in contact, rendering the metal porous, weak, and unsound in structure.

Metals which are easily deposited, such as silver and copper, are comparatively easy to electrically deposit pure, chiefly because it takes a much higher electromotive force or greater density of current to separate most elements that would be likely to contaminate them; but

with such metals as aluminum the case is different, and to obtain the metal free from impurity requires special precautions.

The metal made by the Hall process is exceedingly pure, the only solid impurities being silicon and iron from the ash of the carbon electrodes and impurities in the alumina ores used. The average metal runs over 99 per cent. pure in ordinary commercial work; only about two-tenths of 1 per cent. of iron, with the remainder of the impurities almost all silicon, and perhaps a small amount of hydrogen occasionally occluded.

The difficulties of separation of the metal by electrolysis included not only those enumerated for the ordinary methods of reduction, but the additional one that, in order to obtain the necessary conductivity, the mass to be electrolyzed had to be fluid, and all the salts of aluminum practicable to use (especially the oxid) are either very infusible, or, as in the case of aqueous or acid solutions, more difficult to decompose than the solvents themselves.

Mr. Hall, in the early part of 1886, devised the expedient of *dissolving* the oxid of aluminum in a molten bath of the fluoride of aluminum and the fluoride of a metal more electropositive than aluminum, and passing an electric current through the molten mass. For the reason that not only is the oxid the cheapest pure salt of aluminum to produce in large quantities, but it has the added advantage that its product of decomposition (oxygen) is the most easily taken care of. Carbon anodes are generally used in the process, and the oxygen, uniting with the carbon, forms carbonic-acid gas, which evolves around the surface of the anodes, and is, in fact, the only by-product of the process. The continuity of the process is maintained by fresh additions of alumina to the bath, and the dipping out from the bottom of the pots at stated intervals the metal produced and the replacement of the worn-out anodes.

As the electrolysis of the alumina is complete and no waste by slags or volatilization occurs, the operation of reduction of the metal goes on without loss. There are few solvents of alumina which answer satisfactorily the conditions of retaining at least 25 per cent. of their weight in a molten solution of not over about 1800° F., and whose difficulty of decomposition are greater than the dissolved alumina at the temperature necessary for the work, and whose specific gravity will at this temperature be less than that of the molten aluminum produced, so that the metal will go to the bottom of the bath and be protected, rather than come to the surface and both by oxidation and short-circuiting prevent successful operations. Added to these requirements, the solvent must be reasonably cheap and easily procurable in large quantities and not itself corrode the nascent aluminum produced. It

must also leave no solid by-product to contaminate the bath and thereby prevent continuity of action. The solvent with its contained alumina must, in addition, be a comparatively good conductor of electricity at the temperature required.

Aluminum chlorid was suggested by Deville as a salt to be electrolyzed for the production of aluminum; but experiments have since demonstrated that this salt, highly heated or in a molten condition, is a very poor conductor of electricity.

Aluminum fluoride by itself is altogether too infusible a salt to answer the purpose. It is believed that all of the substances that will answer the varied requirements of a successful process as a solvent for alumina are the double salts embraced in the wording of Hall's [United States] patent No. 400,766: "The fluoride of aluminum, together with the fluoride of a metal more electropositive than aluminum."

The double fluorides of aluminum and sodium, like most electrolytes and gases, as well as mercury and carbon, increase in conductivity with a rise of temperature. The molten solutions used are much better conductors of electricity when charged with from 25 to 30 per cent. of alumina in solution, so that all that is necessary to denote when fresh charges of alumina need to be added is to connect each of the pots with some form of volt-meter and to add fresh alumina to the bath when the voltage increases. The addition of fresh alumina instantly reduces the voltage again to the normal one.

In the comparison of the relative costs of reduction of aluminum by electrolysis and by any chemical smelting process that it would be possible to devise, it can be granted that at least about 78 per cent. of the theoretical maximum electrolytic effect of the current is utilized. It can be further reckoned that an electric horse-power, taken in any considerable quantity per annum, will cost at Niagara Falls at least as low as $30 per annum. At the rate of the deposition of the metal given above, at least 538 pounds of aluminum can be reduced per electric horse-power per annum, at a cost of not over 5 cents per pound for the power. This rate will undoubtedly be considerably decreased in actual practice. Less than an equivalent weight of carbon anodes is expended to the weight of aluminum produced, and in the regular working of the process the loss of the solvent fluoride salts (material used in the solution of the electrolyte) is very small; so that the total cost, including anodes, of the materials used in the production of aluminum, is as low by the use of the electrolytic method as will probably be possible by any other process that may be devised.

Many other processes for the electrolysis of aluminum have been devised. Sinclair Devill, in the 1850's, made aluminum by electrolyz-

ing it from molten solutions of the double chlorid and fluoride of aluminum and sodium, and Kleiner followed in his steps. He endeavored to make aluminum on a commercial scale in the same way by electrolyzing it from the mineral cryolite, the double fluoride of aluminum and sodium.

Pierre Herault devised a process of electrolyzing alumina itself, first melting the ore and then electrolyzing it by the aid of the current in an electric furnace, having a single large vertical carbon anode. It was found impossible, however, to keep the metal in this way from oxidizing without alloying it with one of the heavier metals, as iron or copper. In ordinary practice, not over 10 per cent. or, at most, 20 per cent. of aluminum alloys were produced, which were irregular in composition and expensive on account of the large amount of current required.

Similarly, and at about the same time (1885-88) the Cowles Electric Smelting and Aluminum Company manufactured aluminum alloys with not over 20 per cent. aluminum alloyed with iron or copper, in horizontal electrical furnaces, mixing the aluminum ore with solid carbon and placing it in the pathway of electric currents of large quantity passing between two sets of carbon poles. The carbon at the high temperature of the electric arc reduces the oxid to the metallic state, but at the high temperature necessary to effect the reduction, as in the Herault alloy process, aluminum can not be produced in the metallic state pure by this method, but only in an irregular alloy of 10, or, at most, 20 per cent. of aluminum with copper or iron.

Grabau, a German metallurgical chemist who devised a very meritorious modification of the chemical process of manufacture of of aluminum by the aid of sodium as a reducing agent, has also invented a process of electrolysis of sodium from molten common salt (chlorid of sodium). By this process, the chlorin evolved was collected and utilized in the manufacture of bleaching-powder in this way making the cost of production of metallic sodium very cheap indeed.

The Aluminum and Magnesium Fabrik Company, of Hemelingen, near Bremen, have so far been among the largest manufacturers of magnesium, sodium, and potassium, and at one time made some aluminum by their process, using compound salts containing aluminum chlorid in their electrolyte. The process was not a commercial success for aluminum, and embodied the usual difficulties connected with the corrosion of the anodes and apparatus.

The manufacture of magnesium by economical methods of electrolysis will quite surely be brought out soon, for the uses for cheap magnesium with a specific gravity of only 1.75, against 2.56 for aluminum, will

be large. In other words, "the state of the arts" demands, and the facilities are ready, and the answering cheap production is almost sure to follow in the near future.

Carborundum, the carbide of silicon, is made in an electric furnace by heating for several hours in the path of an electric arc a mixture of 100 parts of sand, 25 parts salt and 25 parts coke. The crystals of carborundum are of a greenish color and have an extraordinary brilliancy. They are also of extreme hardness, which makes the material a very efficient and powerful abrasion agent. Carborundum is the invention of Mr. Edward G. Acheson, of Monongahela City, Pa., and illustrates the further use of the electric current as a powerful agent in the production of chemical reactions.

As a convenient and easily-effected means of separation in quantitative chemical analyses, electrolysis is being used with almost all the metals. And as the methods become better known, they are being more widely adopted. An interesting new use of electrometallurgy is the deposition of metallic salts by the means of electrolysis in the human tissues for therapeutical purposes.

A singular and unfortunate illustration of metallurgical electrolysis has lately demanded public attention in the corrosion of undergound pipes and other metal work by the action of electric currents seeking return conductors to the dynamos of electric railways. When the precautions of a complete and adequate metallic circuit are not taken, the currents seeking the lines of least resistance often take to the water-pipes, and where the surrounding earth is moist, it becomes a sort of electrolyte,—the location where the current jumps to the pipes becoming one of the poles or electrodes, and where it leaves the pipe the other. The moisture of the surrounding earth often charged with acid salts is decomposed; the haloid element, going to the negative pole, naturally occasions a serious corrosion by its action on the metal work, and the cutting out of the material at the positive electrode as well adds to the serious consequences occasioned.

Special developments have lately been successfully made in partial electrolysis of sea-water (giving to it the antiseptic qualities of chlorid of lime), and the use of this liquid in the purification of sewage and other kindred purposes.

Undoubtedly many uses will be made of the powerful oxidizing and reducing agents which can readily be produced, not only by electrolysis but at the poles of electrolytic cells where they may be conducted away or otherwise used as oxidizing or reducing agents. The chief difficulty to be overcome in most cases is to find anodes capable of withstanding the corrosive action to which they are subjected.

THE ELECTRIC TRANSMISSION OF POWER.

By Francis B. Crocker.

SECOND only in importance to the production of energy is the transmission and distribution of power to the various points at which it is applied. Indeed, it may be said that, at the present time, more interest and greater progress exist in connection with the latter branch of engineering. The actual generation of power is practically limited to two methods: (1) the development of mechanical power from the energy contained in fuel by means of steam- or gas-engines and (2) the production of power by means of water-wheels. The latter method is already sufficiently perfected, the turbine-wheel being very efficient, compact, simple, durable, and cheap, leaving little to be desired. The steam-engine and gas-engine are being gradually and surely improved, especially in their efficiency, but there seems to be no probability of a radical advance, and they do not afford very much ground either for discussion or for visions of great possibilities.

The transmission of power, on the other hand, while apparently less fundamental, nevertheless presents a great many extremely interesting problems and has the potentiality of revolutionizing several of the most important methods of modern civilization. The electric transmission of power from Niagara Falls constitutes in itself one of the most remarkable events of this century. The location of large electrical generating-plants directly in the coal-regions from which power will be transmitted to various cities and towns is another great possibility that is not at all remote. Either of these systems could convey energy to distances of fifty or a hundred miles, or more, and supply the power required, not only for manufacturing purposes, but also for ordinary household uses, including lighting, heating, and power as a substitute for manual labor in domestic work. The widespread distribution of power in a cheap and convenient form, for small as well as large users, would tend to have the effect of preventing the concentration of population in manufacturing towns and might become a considerable element in solving the social and moral problems of factory life. In short, the application and the extension of the use of electric power are almost unlimited, and its development will go on with rapid strides during the next few years. The progress made in the last ten years is a mere beginning, compared with what will be accomplished in the future.

Electric-power transmission, like most of the other great branches of engineering, had a very small origin. Barlow's wheel, invented in

1823, and Faraday's disk, brought out in 1831, were the first forms of motor and dynamo, respectively, and the power of both of these machines was almost infinitesimal. Nevertheless, the principles which they contained have been developed until we now have machines of 20,000 horse-power each. The progress in the use of electric power was greatly retarded by the fact that the only available source of current, until within ten or fifteen years, was the primary battery. This source of current is not only inconvenient and bulky, but is also very expensive, the cost of a given amount of electrical energy from it being ten or twenty times as great as that obtained from a dynamo. The rapid and extensive introduction of the latter machine, and the laying of circuits for distributing the current, have had the effect of encouraging a great development of electric power during the past few years. The first experiment in the long-distance transmission of power is that made by Deprez, between Miesbach and Munich, in 1882. The amount of power then transmitted was small, being only one-fourth of 1 horse-power, and even the electrical efficiency obtained was but 38.9 per cent. A much better result was attained by Deprez in 1885, when he transmitted 40 horse-power from Creil to Paris, a distance of thirty-four miles, the commercial efficiency being 53.4 per cent. and the electromotive force being 5717 volts. Unfortunately, one of the machines broke down for the simple reason that the art of insulating the wires had not at that time reached a sufficient state of perfection to permit machines of such high voltage to be made successfully. The general plan of this system, however, was correct, and a precisely similar plant could be put up to-day that would be thoroughly practicable, provided the insulation and other details of construction were made according to the modern perfected methods. A little later other plants were installed to transmit electric power in Switzerland and in this country, but the distances were not very great, being only ten or fifteen miles.

In 1891, a plant was designed and constructed to transmit energy from the water-power at Lauffen to the Electrical Exposition then being held in Frankfort, Germany,—a distance of 109 miles. This experiment was of extraordinary interest, not only on account of the great distance, but because it also involved the use of the new three-phase alternating current, which is probably the greatest addition to electrical engineering in recent times. The amount of power transmitted (about 100 horse-power) was not quite as great as was expected, but it was sufficient to make the experiment thoroughly practical, and the efficiency obtained, which was about 75 per cent., demonstrated the economy of the method. During the last two or three years many plants have been put in for transmitting electric power over distances of fifteen or twenty miles, or more. These have been so successful that almost

every water-power within a reasonable distance of any large city or town is already or soon will be utilized in this way. Many of these water-powers would otherwise be entirely unavailable and worthless. An enormous plant is now being installed at Niagara, by means of which 200,000 horse-power of electric current will be generated and transmitted to various points, not only near the Falls, but also to Buffalo and other places. Since the power of Niagara is estimated to be 20,000,000 horse-power, which is many times greater than the entire power now used by man, it is evident that the utilization of this power is limited only by the distances to which it can be carried and by the number of persons and machines that may be located within that range. Other water-powers not so great, but nevertheless sufficiently large for local use, are available all over the world. The distribution of power from coal-regions, which has already been referred to, may also become of very great importance in the future. By this system not only would the expense of handing and transportation be saved,—and this constitutes the principal part of the cost of coal,—but also the smoke, dirt, and trouble incidental to the use of coal would be entirely avoided.

A system for the electric transmission of power comprises the generating-plant, the line, and the receiving-plant.

The generating-plant consists of one or more dynamos driven by steam- or gas-engines, and the various switches, instruments, etc., required to control and measure the current produced. The line consists of metallic conductors, usually copper wires, which connect and convey the current from the generating- to the receiving-plant. The line should be well insulated to prevent the leakage of current from it.

The receiving-plant consists of one or more electric motors which are driven by the current transmitted over the line, and they produce mechanical power which can be used for any desired purpose. These motors can all be located at one station or they may be distributed at various points where power is required.

The cost of the line becomes a very large item if its length is great; in fact, this is the principal limitation to the distance to which power can be transmitted. The size of the wire required, and consequently the cost of the line, can be reduced by the use of higher electrical pressures,—*i. e.*, currents having an electromotive force of several thousand volts. This is analogous to the fact that a given quantity of water or steam can be carried to a greater distance and through smaller pipes if the pressure be high.

Electrical power is measured in watts, which are the product of the volts and the amperes; hence we can obtain 746 watts, which is equal to 1 horse-power, either by having 74.6 volts and 10 amperes, or 746 volts and 1 ampere. In the latter case the current has only one-tenth

the value and, since the size—*i. e.*, cross-section—of wire required is directly proportional to the current, it follows that the weight of wire is only one-tenth as great, with ten times the electrical pressure. This merely takes account of the actual current capacity of the line, but if we consider the *percentage* of loss on the line, the advantage of high pressure becomes still greater. The reason for this is evident from the law that the loss of energy in a conductor is proportional to the square of the current and to the resistance; in fact, it is commonly called the C^2 R loss. Hence, the loss of energy in a given wire is 100 times greater with 10 amperes than with 1 ampere, and the wire must therefore have 100 times the cross-section and weight in order to have the same loss.

This enormous economy in copper, secured by the use of high electrical pressure, practically forces us to employ the highest allowable voltage, whatever may be the particular system or kind of current employed. Currents of 15,000 or 20,000 volts have already been used, and 50,000 volts are now recommended by electrical engineering authorities.

The problem of long-distance power-transmission has practically resolved itself into the question of constructing generators, lines, motors, etc., capable of operating with these extremely high voltages without injury to the apparatus itself or to persons and property.

Four different systems are available for the purpose, according to the character of current employed: (1) direct current; (2) simple alternating current ("single phase"); (3) two-phase alternating currents; and (4) three-phase alternating currents.

Any one of these four systems might be employed for either short or long distances, and combinations of two or more of them might be adopted advantageously in certain cases. The difference between these various kinds of current and the relative advantages and disadvantages of each is a much discussed matter at the present time. The probability is that there is no general solution of this problem, and that each particular case would have to be decided on its merits. In the most common cases of power-transmission the distance varies from ten to thirty miles, and any of these four methods could be used so that it is often difficult to decide which is the best. The proper way to consider the matter is to study each system and carefully weigh its advantages and disadvantages.

The direct-current system could employ a single dynamo to generate the current, but for long distances it would be better to connect two or more machines in series, and this applies also to the motors. In this way the total electrical pressure would be subdivided and the voltage that would have to be carried by each commutator would only be a fraction of the whole amount. Very high electrical pressures might

cause a commutator to flash badly. Hence the necessity for having a commutator is the chief objection to the direct-current system, but since machines of 5000 volts are in regular and successful use for arc-lighting, it would be possible to obtain 20,000 volts from four of such machines in series. The subdivision of the pressure would also reduce the danger of breaking down the insulation of the machines.

Another disadvantage of the direct-current system is the fact that it requires a dynamotor to transform it from a higher to a lower pressure, or vice versa. This machine is a combination of a motor and a dynamo, and is more expensive and likely to get out of order than the simple stationary induction coil which is used to transform the alternating current.

The direct current has the advantage over the alternating-current system in the fact that it is entirely free from any loss or disturbance due to the static capacity and self induction of the line. These two matters are somewhat technical, but they play an important part in all electrical circuits, in which alternating or variable currents are used. The effect of self induction is to cause a very considerable fall in electrical pressure and the effect of static capacity is to absorb and give out, as it were, a considerable quantity of electricity each time the line is charged and discharged by action of the alternating current, which in ordinary practice reverses its direction of flow 50 to 250 times per second.

The direct current experiences no loss whatever from self induction or capacity, the pressure lost being merely that required to overcome the resistance of the line expressed in ohms, which loss also occurs with the various forms of alternating current in addition to the peculiar actions referred to. Besides the separate effects produced by static capacity and self induction, it is also found, when these two factors bear a certain relation to each other, that the peculiar phenomenon of electrical resonance occurs, putting the line into an extremely sensitive condition and causing abnormal rise of electrical pressure at certain points. This might act as a disturbing element and even break down the insulation of the machines, transformers, or line. On the other hand, it is often attempted to neutralize the bad effect of either static capacity or self induction by balancing one against the other. But this matter is still very new, having become part of electrical engineering only during the past year, and at present it exists as a rather doubtful question in alternating-current work.

The simple alternating-current system as used for electric-lighting can be adapted to power-transmission. For example, it is possible to take two alternating-current dynamos of the ordinary form and use one as a generator and the other as a motor. The difficulty, however, is

that the motor must be started and brought up to exact *synchronism* in speed with the generator by some other power before it will run by itself and then, if for any reason it happens to be thrown out of perfect agreement in speed, it will stop entirely. The objection to having some auxiliary power to start the motors and the liability of the latter's being stopped by any load being suddenly put upon them makes this system somewhat unpopular for general use at the present time, particularly if there were a large number of motors. Self-starting motors for the simple ("single phase") alternating current have been devised, but up to the present they are not found in extensive use. There is a great demand for a thoroughly practical motor of this kind and it is to be hoped that they will soon be available in all sizes.

The advantages of this system are its simplicity and the ability to convert from any given voltage to any other by means of a very simple transformer, consisting of a core of iron upon which there are two coils of wire, all the parts being stationary. The simplicity of the alternating-current transformer is really the great advantage of the single-phase as well as the two- and three-phase systems. For example, the dynamo may be constructed to generate a harmless current of say 200 volts, and by means of a "step-up" transformer it is changed to say 25,000 volts, which is suitable to long-distance power-transmission. At the receiving end of the line the current can again be changed by "step-down" transformers to 200 or any other number of volts for use in the motors.

If desired, the 25,000-volt current can be first transformed to 1000 volts to make it suitable for distributing through the streets of a city, and again transformed at each house to 100 volts to be used for supplying incandescent lamps or motors. The efficiency of a transformer is so remarkably high, being 96 or 97 per cent., that several transformers can be made with a total loss of only 5 or 10 per cent.

The two-phase alternating current really consists of two simple alternating currents of the ordinary kind which differ in phase; that is, when one current has its maximum strength the other is just reversing and vice versa.

These two currents may be carried on entirely distinct circuits by separate wires having no electrical connection with each other, or, for the sake of economy, the return wires of the two circuits may be combined as one wire, making three conductors in all. The two-phase current, when applied to a magnet made in the form of a ring, tends to produce a continuous rotation of the polarity, so that a bar of iron pivoted at its center and placed within the ring magnet will revolve with the polarity being drawn around by it. This takes by the magnetic attraction through the air without any magnetic or electrical contact with the revolving bar. This very beautiful and at the same time

practical method of producing rotation is substantially the principle of the two-phase motor. In practice the revolving armature is not a mere bar of iron, but it is of simple construction and requires no electrical connection to be made to it and this fact constitutes the essential advantage of the two-phase motor. Its disadvantages are the fact that three or four wires are required for the circuit instead of two, and for electric-lighting the two circuits are apt to affect one another and cause variations in the lamps. These are in addition to the general troubles which occur with alternating currents, as already stated.

The three-phase alternating current consists of three currents differing in phase. In this case the three circuits act mutually in such a perfect manner that three wires are sufficient, and each wire serves successively as the return for the other two. The general principle of this system is similar to that of the two-phase, and it is also specifically applicable to power-transmission.

The single-phase, the two-phase, and the three-phase alternating-current motors may be likened to the single, double, and triple cylinder steam-engines. In the single-cylinder engine the steam-pressure is applied back and forth in the same line and the engine is liable to be caught on the dead-center, in which case it is not self-starting; in fact, a fly-wheel is required to carry it over the dead-center in order to produce continuous rotation even after it is started. In an analogous manner the single-phase motor is not ordinarily self-starting and requires some device to carry it over the dead-center. A two-cylinder engine, such as the locomotive, for example, having the cranks at right angles to each other, is always self-starting for the reason that when one is on the dead-center the other is in its most effective position. The two-phase current acts similarly by forces applied at right angles to each other, producing a continuous rotary effect.

The three-phase current, like the three-cylinder engine, secures, by the combination of three forces acting at angles of 120° to each other, a still more uniform and perfect effect.

In conclusion, it may be remarked that the whole subject of electric power-transmission is still an undecided one. The two- and three-phase systems, which may be considered together under the title of polyphase, since they are not materially different, are now claimed to be preferable to either the direct-current or single-phase systems, but some engineers advocate the latter two methods, and in many cases they would certainly be more desirable. The probability is that in this, as in many other branches of engineering, each system or form of apparatus has its proper application and sphere of usefulness, and that there is no *universal* system or type of machine for all uses.

THE PRESENT AND FUTURE LOCOMOTIVE.

By David L. Barnes, M. Am. Soc. C. E.

THE demand for quick transit for both passenger and freight trains and the need for all possible reduction of operating expenses make the development of the locomotive an interesting subject, especially in the matter of the limitation to the increase of size. There is a point beyond which the locomotive cannot be increased in weight and power without passing the most economical plan of operating a railroad. In slow freight service the limit is found when a further increase of train-load so increases the cost of fuel and loss due to delayed freight that there is a greater total cost of transportation per useful ton-mile,—"useful ton-mile" being one ton of paid freight hauled one mile. The chief advantage of heavy freight-trains is found in the decreased cost of wages and locomotive expenses, outside of fuel, per useful ton-mile. Two disadvantages are the decreased efficiency of the boilers when forced to a greater degree and the more frequent delays to freight caused by the heavy loads, *per se*, and by the parting of couplers between cars under the heavier strains. On level roads, with strong car-couplers, Westinghouse brakes, and large locomotive-boilers, the maximum economical train-weight is high, while on uneven roads, with ordinary link-couplers and with boilers having small grates, the maximum is comparatively low.

Where fuel is high in price, as in Mexico (about $18 a ton), and wages are low, the maximum economical train-weight has been reached for the present; a further increase must wait for a cheaper fuel. The steam-cylinders and boilers of locomotives are generally worked above the most economical point, and an increase of load reduces the efficiency. Hence, where fuel is excessively high, it is generally the case that additional loads cost more in fuel than is saved in other ways.

In passenger service the limit of train-weight is always found in the speed; each increase of speed demands an additional amount of steam per minute and, consequently, there is an increased demand on the boiler. This would be true even if the train resistance did not increase with the speed, for the reason that with the same resistance the distance traveled over is greater at the higher speed in the same time; therefore more work is done and more steam must be used per minute. In fast freight service the limit of train-weight is found in speed, just as in the passenger service.

With locomotives the weight of fuel used per square foot of grate an hour, or what is called the "rate of fuel use," is enormous when

compared to stationary-boiler practice, and the blast is so fierce that much of the fuel is drawn through the tubes and passes to the stack unburned and wasted. The approximate diagram Figure 1 indicates several important conclusions, viz. :

The weight of fuel used per square foot of grate an hour in locomotive-boilers in railroad practice in the United States is fully eight times that used in stationary boilers, and three times that used in locomotives in England and on the continent of Europe. On heavy grades the rate of fuel used is much higher than on level track, and each increase in the rate causes a decrease in the efficiency of the boiler. The words "fuel used" are here employed instead of the more common expression "fuel burned," for the reason that much of the coal shoveled into locomotive fire-boxes is not burned, but goes unburned through the smoke-stack in the form of cinders. From the diagram Figure 1 it is clear that the best practical economy is obtained only by using fuel at a rate at which it can be well burned; it is also seen that there is a limit to the train-weight that can be hauled with reasonable economy in the use of fuel.

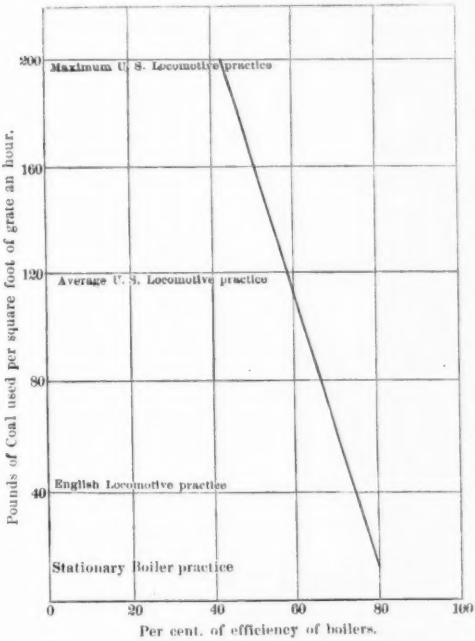


FIG. 1—DIAGRAM SHOWING REDUCTION OF EFFICIENCY DUE TO FORCING LOCOMOTIVE BOILERS.

The diagram Figure 2 shows approximately how the fuel required per ton-mile changes when the same locomotive is used and the load is increased or reduced. The diagram Figure 3 shows how the maximum attainable steam-power, with reasonable efficiency, decreases as the speed increases on the same locomotive when the parts are well de-

signed and the valve-motion is of the Stephenson link type. The decrease in power results from two things: the friction of the steam in passing through the passages and the decrease in the amount of steam admitted to the cylinders at each stroke.

One might ask, why not admit more steam? The reply is, that the largest amount of steam that can be admitted without "choking up" the engine to an uneconomical point is generally admitted now, and also that, if the engine is run with a long cut-off and the power is regulated by the throttle, this being the method by which the most power can be obtained at high speeds, the efficiency is greatly reduced and the boiler is more severely taxed.

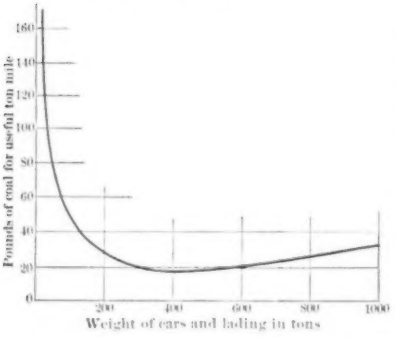


FIG. 2.—DIAGRAM SHOWING APPROXIMATELY THE FUEL REQUIRED PER TON-MILE WITH DIFFERENT TRAIN-LOADS.

Where the efficiency of the locomotive is a secondary consideration and the speed is the most important factor, then the limit of speed is found in the steaming capacity of the boiler, and it must be found by actual trial in each case whether, with a given locomotive, more power for hauling trains can be obtained for long runs by disregarding the efficiency and using the steam in the cylinders with a long cut-off and regulating with the throttle, or by using a short cut-off and regulating with the reverse lever. For a short time the boiler can be drawn upon for an unusual supply, but for a long run the maximum power of a locomotive will probably always be had when the steam is used in the cylinders with the highest efficiency, and experience has practically proved that the maxium limit of load for a long run is reached when the steaming capacity of the

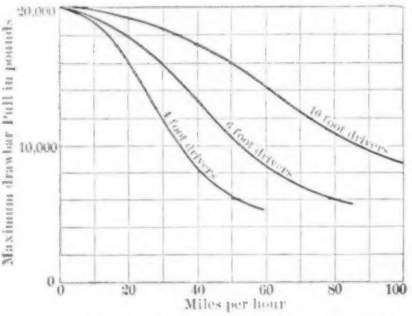


FIG. 3.—DIAGRAM SHOWING DECREASE OF MAXIMUM ATTAINABLE STEAM-POWER AS THE SPEED IS INCREASED.

boiler and the efficiency of the cylinders are nearly at a maximum.

The diagram Figure 4 shows approximately the variation of train resistance for different uniform speeds. When the speed is changing the resistance is quite different from that shown on the diagram, as it is materially affected by the inertia of the train. When the speed is increasing the inertia increases the resistance and when the speed is decreasing the resistance is decreased. Figure 5 shows approximately how the inertia affects the resistance in starting out from a station and accelerating a light passenger-train on a level track to eighty miles an hour. These diagrams are based on the few tests that have been made up to ninety miles an hour, and are based on the assumption that the bearings have been warmed by running. If the train has been standing a long time at a station before starting, the resistance from the

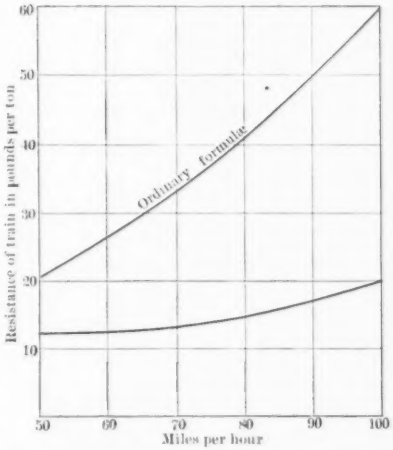


FIG. 4.—DIAGRAM SHOWING ERRORS IN ORDINARY FORMULÆ FOR TRAIN RESISTANCE AT HIGH SPEEDS.

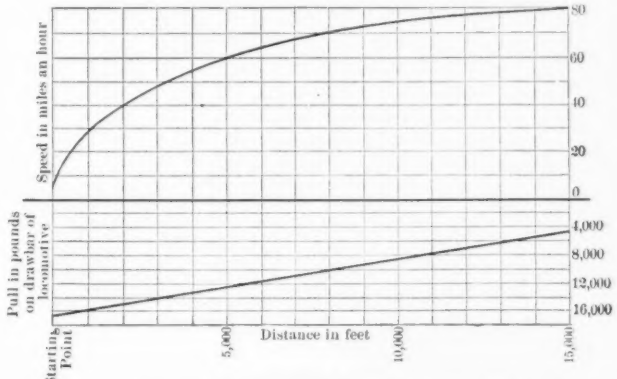


FIG. 5.—DIAGRAM SHOWING THE EFFECT OF INERTIA ON THE TRAIN RESISTANCE WHEN THE VELOCITY IS INCREASING.

starting-point to a speed of thirty miles an hour is greatly increased. The air-resistance is not so great as has been understood from the formulæ that are given in technical books. If these formulæ were correct, railroad trains could not be hauled at one hundred miles an hour by our present equipment. Take, for instance, the Empire State Express train, of 283 tons. The formula for resistance often given is $\frac{V^2}{171} + 8$. This would give a resistance of 66.5 pounds per ton on a level, or, for the whole train, 18,800 pounds. This would require at least 5000 horse-power to be generated by the engine, and is, of course, impossible. Probably 1200 or 1400 horse-power is the maximum capacity of the Empire State Express locomotive, and the resistance is more nearly what is shown by the diagram, Figure 4. Figure 6 shows the resistances due to grades alone; these are not included in the diagrams Figures 4 and 5.

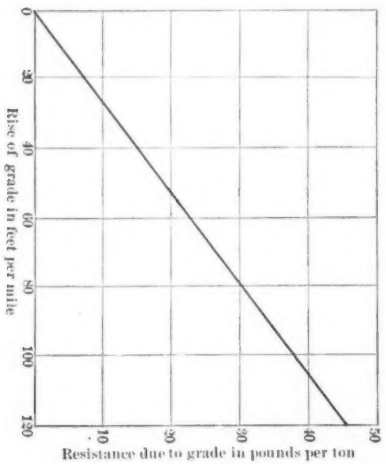


FIG 6.—DIAGRAM SHOWING THE RESISTANCE DUE SOLELY TO GRADES AND NOT INCLUDING THE FRICTION OF AXLES.

The limit of locomotive boiler-power is nearly reached at present, and, unless two separate grates are used, no more fuel can be burned on a locomotive than can now be burned with the largest grates we have in use. A grate ten feet long is about as long as a fireman can care for properly, and when it is as wide as the present Wootten grates it can be no wider without exceeding the maximum allowable width of a locomotive. It is evident that two separate grates, placed one ahead of the other, will be necessary if much more fuel must be used than can be burned at the present time. Two grates would require practically two boilers to give the necessary heating-surface, and would lead to changes and complications that are not permissible so far as can now be seen.

The gain in economy to be derived from the use of two boilers would be very small, and the gain in weight of trains at high speed that would be possible with the double grate would probably not reduce the expenses per passenger-mile enough to pay for the trouble

incident to the use of two large boilers on one locomotive. It might be said that such an increase of boiler-power would permit an increase of speed, and so it would, but a speed of one hundred miles an hour is possible now with light trains on straight track, and that is as fast as it will be safe to travel until better protection is given to trains while running, and even then it will not be safe until passenger-cars are made of metal and adapted to resist shocks without breaking into sharp and ragged fragments, which are a menace to life. One wreck or a collision at one hundred miles an hour, even with the best of our wooden equipment, will greatly cool the ardor of high-speed enthusiasts.

In all discussions of high speed it should be remembered that a high maximum speed is not what is wanted, but a high average speed. The saving of time between terminals depends upon the average speed, not upon the maximum. The maximum may be high and yet the average be low. A quick run from New York city to Chicago would be eighteen hours, and this would require an average speed of only fifty-five miles an hour. A maximum speed of one hundred miles an hour is unnecessarily high to give an average of fifty-five miles. The distance from Jersey City to Philadelphia is ninety miles and the run is now made in 1.95 hours, which gives an average speed of forty-six miles an hour. To make the run in 1.5 hours requires an average speed of but sixty miles an hour, so that it is clear that the high speed now asked for by the public is not a high maximum but a high average, and to meet the demand for quick service there must be steady running at a reasonable speed. High maximum speed is spectacular but not practical, while high average speed is a real necessity, and can be obtained; for such service locomotives need power at starting and a larger boiler-capacity for work on light grades. High average speed on heavy grades is impossible within the limits of steam locomotive construction. A grade of 1 per cent. demands about 1500 additional horse-power at one hundred miles an hour, and 900 additional horse-power at sixty miles an hour, in the case of the Empire State Express train. This shows how a light grade may increase greatly the demand on the locomotive boilers at high speed. Probably the most feasible way of making quick time between terminals is to give the trains a clear track and reduce as much as possible the curves and grades, just as has been done by the Lake Shore and Michigan Southern road within a few years.

The present light freight engine is shown by Figure 7, the heavy freight engine by Figure 8, and the usual mountain type by Figures 9 and 10. These types are varied somewhat by changes in the type of boiler and in the dimensions of the wheel-bases and wheels, and in the location of the trucks, but in the main the illustrations show the best present designs. In the future, steam freight locomotives will prob-

ably be made on these lines with no radical changes. The limit of increase of dimensions must be governed by the maximum single grate that can be properly fired. No doubt there will be changes in the boilers and cylinders that will increase the efficiency and, generally speaking, the weight of trains can be increased when the efficiency is increased. The use of compound cylinders and high steam-pressures gives a higher efficiency and permits more useful work to be done by the steam generated with a given boiler-capacity; probably, then, the principal differences between the present steam freight locomotive and that of the next decade will be found in the compound cylinders, the increased steam-pressure, and the small increase of grate-area and heating-surface of the boilers, but the type of locomotive undoubtedly will remain about as it is now.

For suburban work there have been many recent improvements in design. Formerly old locomotives taken from main-line service were used, but now special designs have been introduced and the type shown by Figure 11 may be taken as representing that of the near future, that is, until the electric motor replaces the steam locomotive for this class of work. The simplicity of construction and the high efficiency when the cylinders are made compound give to this type its principal advantage.

In passenger service some decided improvements have been made in the past ten years, and the dimensions of the boilers have in some instances practically reached the limit of extension for a locomotive carried on four drivers. The largest grate-area and boiler-capacity is that given by the Wootten boiler locomotive, Figure 12, which is a new type known as the "Flying Dutchman." A similar type is the "Columbia," shown in Figure 13. This locomotive is a four-cylinder compound. One of the most important and the very latest modification of the present standard type of high speed passenger locomotives is the two-cylinder compound No. 1515 of the Pennsylvania road, Figure 14. For heavy passenger service with moderate speed the ten-wheel freight type, Figure 7, is quite extensively used, but the wheels are generally made about one foot larger in diameter for passenger service.

These are the distinct types of passenger locomotives that are now considered generally useful, and no other type has been offered that appears more desirable or that will give more advantages than these. In the case of the Wootten boiler the grate-area is nearly, if not quite, at the maximum that can be properly fired from one end. The weight per wheel of passenger locomotives is already near the limit that is safe on present track and bridges. The steel bridges now built are practically permanent and the best roadbeds are about as stable as it is economical to make them. Some passenger locomotives have now all the boiler-

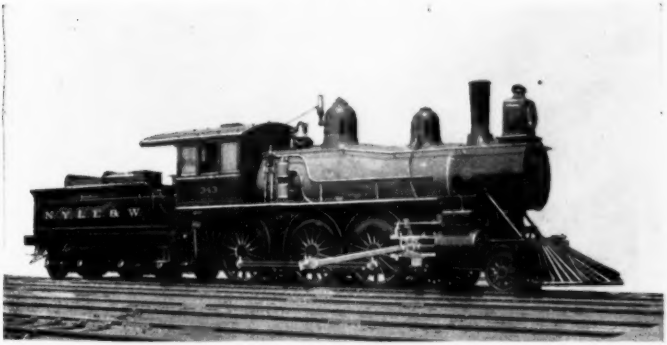


FIG. 7—MODERN TEN-WHEEL FREIGHT AND PASSENGER LOCOMOTIVE.

power that can be given them without passing the limit of weight, and it is probable, therefore, that in the future the steam passenger locomotive will not be changed much, although the weight and power may be increased a little. The demand for quick runs over long distances will not be filled by building locomotives for excessive speeds, but by so arranging the time-tables and decreasing the curves, grades, and number of stops that high uniform speeds can be maintained for considerable periods of time. The erratic designs of locomotives, such as the Fontaine, the single driver without parallel rods, the Polygonal driving-wheel, the Shaw locomotive, and other marked departures from types

FIG. 8—MODERN HEAVY FREIGHT LOCOMOTIVE, CONSOLIDATION TYPE.

FIG. 9.—MOUNTAIN CLIMBER, DACAPOD TYPE.

that have been developed by actual service, have not brought out a single feature that it is desirable to add to the present standard design, and radical changes are not to be expected in the future.

One of the most disputed points has been the use of the parallel rods, and American railroad-men have been criticised by Europeans for using parallel rods for high-speed locomotives, but, after long experience in Europe without the parallel rod, and in this country with it, the rod remains, and its use has been justified by experience. In Europe the newer types of engines have the driving-wheels coupled

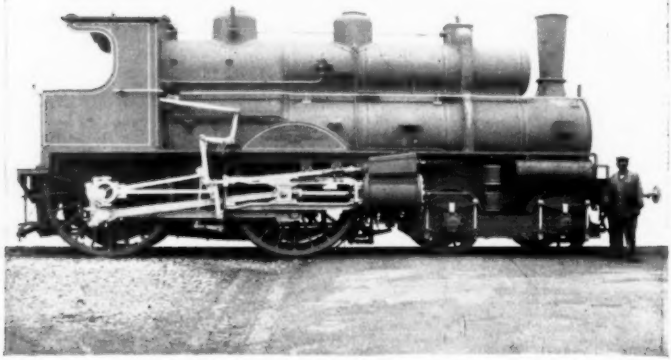


FIG 10.—MOUNTAIN CLIMBER WITH TANK, DACAPOD TYPE.

together by rods to gain the increased adhesion that is needed for making high average speed, which is, as has been here shown, the essential element of the quick average running asked for by the public.

So far only steam locomotives have been considered, but something should be said about the possibility of the electric locomotive. The future locomotive in some cases will certainly be driven, as now by steam, but where very high maximum speeds are needed and grades are to be traveled over at considerable velocity, and on suburban lines and sections where the traffic is crowded, electricity will be the motive-power. The reasons are clear from what precedes, as the necessary boiler-capacity cannot be given to a locomotive to permit high train velocity on the grades that are now common on main lines. With electricity

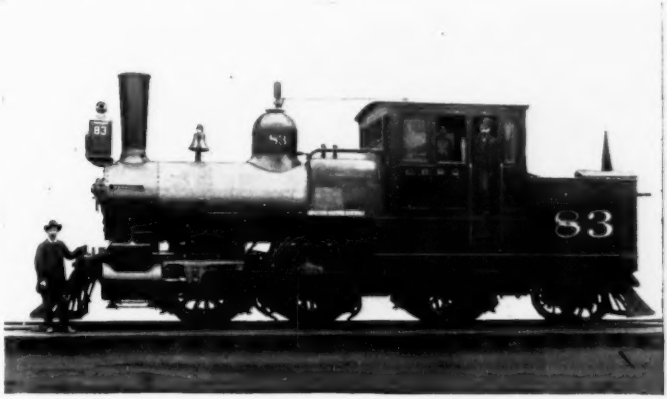


FIG. 11.—MODERN SUBURBAN LOCOMOTIVE.

any reasonable amount of power can be supplied from the central station, where room may be provided for any desired boiler-capacity.

It is not at all probable that the immediate future will find electric locomotives taking the place of steam on main lines for regular work, as the expense of installation is out of proportion to the advantages to be gained by the change, but for elevated roads, suburban work, and switching, the change will be rapid after a few actual plants have proved the practical superiority of electric transmission. The present experience with electric motors in England and in this country for quite heavy trains is enough to establish an important conclusion: namely, that the transmission of power from a central station by the electric current, and its transformation into mechanical work at the train by means of electric motors, is a practicable and efficient method of fur-

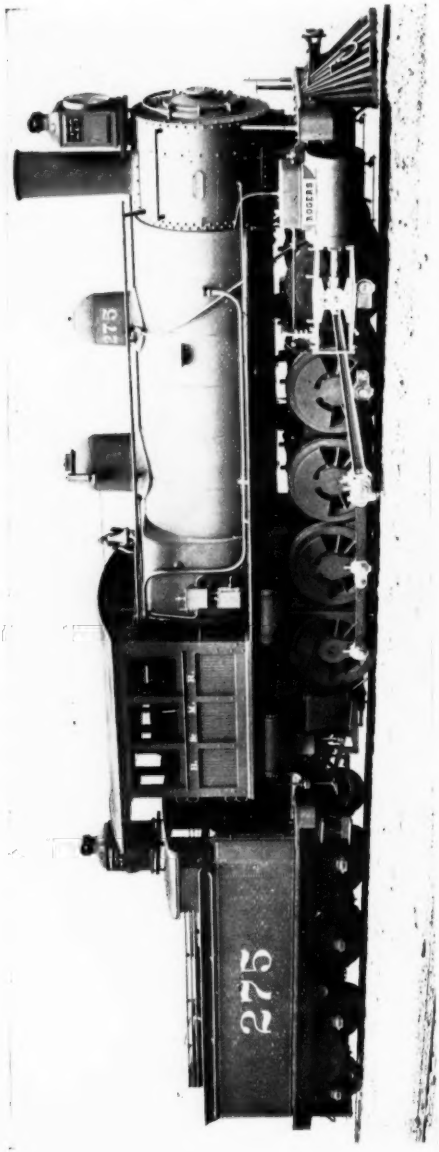


FIG. 12 — HIGH-SPEED PASSENGER LOCOMOTIVE, "FLYING DUTCHMAN" TYPE.

nishing power to locomotives, while the cost of fuel and repairs is less than with the steam locomotive: but the other expenses, that are made up of interest, taxes, ground-rent, etc., are dependent upon a multitude of conditions peculiar to each railroad, and the final relative economies of the two systems must be learned from a study of the conditions existing in each particular case.

To sum up, we are now entering upon an era of change of motive power from steam directly applied, as in our present steam locomotives, to electric transference of power from a central station to moving trains. The change must necessarily go on slowly, commencing first with the suburban, switching, and elevated services, and finally beginning in main-line work where the traffic is crowded. The steam locomotive

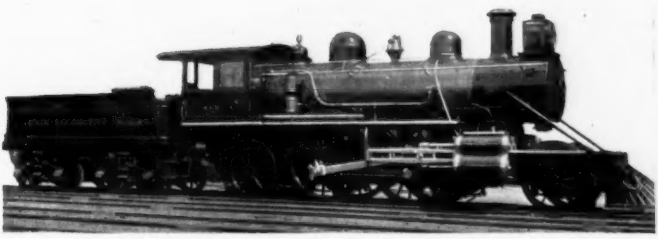


FIG. 13—HIGH-SPEED EXPRESS LOCOMOTIVE, "FLYING DUTCHMAN TYPE," FOUR-CYLINDER COMPOUND.

will not be altered much in appearance or power from the best of the present designs, but improvements will continue in detail so long as it remains in use. We are nearly at the limit of economy with steam locomotives where there are large boilers and compound cylinders, and where the engineer and fireman are competent and the loads not excessive, and the maximum capacity is about as great in some cases as it is practicable to make it; hence, for higher efficiency and greatly increased hauling power at high speed, concentration of power is needed. So far as can now be seen there must be a stationary plant where power can be concentrated, and electricity seems the only practical means of transferring such concentrated power to moving trains.

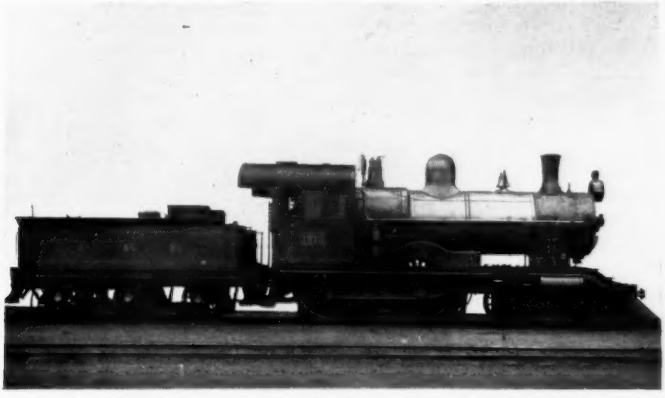


FIG. 14—POWERFUL EXPRESS LOCOMOTIVE, TWO-CYLINDER COMPOUND.

ELECTRICITY

Conducted by Franklin L. Pope.

IT is evident that the time is rapidly approaching when all conductors for electric-light and -power service, at least in large cities, will have to be laid underground. In that event, it will be a matter of great moment that effectual means shall previously have been devised by which incandescent, arc, and motor service, or other kinds of service, may be taken from a single generator and a single pair of conductors. It has already become evident that the key to the solution of this problem is to be looked for in some development of the polyphase system. During the past year, much space has been occupied in the technical papers in the discussion of the respective advantages offered by the two-phase and the three-phase methods of transmission. Perhaps the most striking paper on the subject which has as yet been presented, and certainly one of the most valuable from a practical point of view, is that of Mr. Charles F. Scott, which was read at the annual meeting of the National Electric Light Association, and which should have received earlier notice in this Department. In the management of the larger class of alternating-current stations, some very perplexing phenomena have from time to time presented themselves; phenomena which have served to puzzle some of our most accomplished electricians. It is but simple justice to the author of this paper to say that he has made the occult causes of most of these mysteries so plain that they may be easily comprehended by any ordinarily intelligent electrician. Commencing with some experimental illustrations of the curious effects of self-induction in alternating circuits, which are well illustrated with diagrams really illustrative in their character, Mr. Scott passes to the consideration of the phenomena of fall of potential or "drop," in both direct and alternating circuits, which prepares the way for the discussion of the two vital factors in alternating distribution, loss, and regulation, the Scylla and Charybdis of the electrical engineer. The methods by which the drop of an alternating circuit is computed are next taken up, and a most ingenious chart is given, showing at a glance the inductive electromotive force in volts per ampere per thousand alternations per thousand feet of circuit, at different distances between centers of conductors, which has been warmly praised by Professor Forbes and other prominent electrical engineers, and which cannot but be of the utmost service to the future designers of large plants for the transmission and distribution of electric power. The phenomena of self-induction as affecting the converter, are discussed and the methods of testing these appliances explained. More than one station-manager has been worried nearly to distraction by unaccountable fluctuations in the brilliancy of the incandescent lights at the end of a long circuit, occurring with monotonous regularity and baffling all his efforts to locate the source of the trouble. Mr. Scott shows this effect to be due to the mutual induction set up under certain conditions between two parallel circuits on the same line of poles, producing an action and reaction analogous to that in the primary and secondary circuits of a transformer. But perhaps the most important part of the paper is Mr. Scott's discussion of the relative advantages of the two-phase and the three-phase methods of distribution. The author contends that the three-phase, three-wire method requires 23 per cent. less copper for transmitting a given amount of power under otherwise equivalent conditions, which in many cases is a matter of considerable importance. There are other conditions which tend to increase this ad-

vantage, among which may be mentioned the fact that the drop due to self-induction is ordinarily only about one-third as great. On the other hand, the two-phase method is admitted to possess important advantages in operating a lighting service, in which one or another branch of the system is liable to become overloaded. The ease and simplicity of installation are also much in favor of the two phase method. With these facts in mind, Mr. Scott describes a method of his own invention, in which he has attempted, and apparently with success, to combine in one system the advantages of the three-phase method for transmission and of the two-phase method for distribution, which he proposes to effect by a peculiar organization of converters at the center of distribution. The loss of efficiency at the point of conversion from one method to the other, has been experimentally determined to be no more than one-tenth of 1 per cent. It is believed by prominent electricians who have expressed their opinions on the subject that Mr. Scott's paper is destined to mark an important era in the science of electrical power-transmission.

IN the annual report of Mr. Andrew Rosewater, city engineer of Omaha, Neb., the problem of making a great manufacturing center of that city by means of a water-power situated seven miles away receives the consideration which its importance merits. Mr. Rosewater computes that the cost of a net horse-power at the water-wheel shaft will be from $8.08 to $9.60 per annum, according as the plant is laid out for twenty-four or ten hours service per day. The cost of a net horse-power in the city, by electrical transmission, is estimated at from $23.59 to $25.76 per annum. The cost of installation of the hydraulic plant is figured at $67.33 and $80 per horse-power, respectively, and that of the electrical plant, at present prices, at about $73 per horse-power. Mr. Rosewater estimates that an equal amount of power (20,000 horse-power) can be delivered by a compressed-air system of transmission at $19.98 per horse-power. The final conclusion is, that while electrical transmission is preferable for such power as may be needed for strictly electrical purposes, such as street-car service and illumination, compressed air offers many advantages over electricity for general power distribution. It is probable that Mr. Rosewater's figures and conclusions will be vigorously criticised by electrical engineers, but he seems, nevertheless, to have given the whole problem very careful consideration.

THE *Electrical World* points out that the column given in many electric wire-tables, showing the number of feet per ohm of different sizes of conductors, may be made to serve to show also the number of ampere-feet per volt. This will be useful in many computations. For example, in calculating the field-winding of a dynamo, find the ampere turns required and then the ampere-feet. If this be divided by the voltage, the quotient is the ampere feet per volt that the right size of wire will give. The table will then show the nearest size of wire to be used.

A CENTRAL station at Lexington, Ky., operating about 7000 incandescent lights, has for some months been using two recording volt-meters, one being in the station, and the other at one of the principal centers of distribution more than a mile away. The first charts taken showed that the pressure varied anywhere from 49 to 56 volts, but the dynamo-men have apparently become much more careful of late, as the recent cards show a very small variation during the 24 hours. Mr. E. J. Richards, the superintendent of the station, says that these instruments have more than paid for themselves in three months by the reduction in the number of lamp renewals.

THE Grand Central station, in New York city, was formerly lighted by 1400 incandescent lamps on 110 volt circuits. Since 1890 these have been gradually replaced by low-tension arc lamps, placed two in series, until at length all the incandescent lamps have disappeared. It is found that 90 arc lamps, consuming 360

amperes, give at least five times as much light as did the 1400 incandescents, consuming 700 amperes. The outgoing-train house, which has an area of 144,000 square feet, is most satisfactorily lighted with 32 arc lamps, which supplanted something like 500 incandescents.

SOME time ago, the General Electric Co. established at its works in Schenectady a student's course of instruction in electrical engineering, intended for young men who have had at least three years, experience in electrical or machine-shop work, or who have obtained from some technical institution the decree of civil, mechanical, or electrical engineer. At first the company felt compelled to exact a fee for admission to this course, but experience soon demonstrated that this had the effect of excluding the very kind of men who were likely to be of most value to the company—those who had worked their own way through college, but who could not afford to pay the fee, and hence the requirement was abolished. The object of the course is to give the student a thorough practical knowledge of the various processes through which a piece of electrical apparatus is carried while in course of construction, and also of the electrical and mechanical principles involved in the different operations. He is placed for a stated time in each of the departments of the works, in which he is required to perform actual work under the supervision of the foreman, and receives such instruction as will enable him to do so. The time occupied by the complete course is ordinarily expected to be about two years, and the learner is paid at rates varying from 8 to 17½ cents per hour, according to his experience and proficiency. The students are required in all cases to observe the same rules and regulations as the regular workmen respecting conduct and hours of work. It is stated that the complement of students is at present filled, and that there is likely to be no vacancy during the present year.

IN a small electric-lighting station at Allegan, Mich., two direct-current 25-kilowatt generators are driven by a 60-inch turbine on a vertical shaft, by means of a quarter-turn endless belt. The belt is 16 inches wide and 70 feet long. Two idler pulleys are set in a movable frame, each at an angle of 45°, and the slack of the belt is adjustable by a hand-screw which moves the frame. The device has been in use for some time and has given the most satisfactory results, being found to be far superior to the bevel-gearing ordinarily used under similar conditions.

THE John A. Roebling's Sons Co. (of Trenton, N. J.) have furnished 500 tons of copper wire for the new Atlantic cable now being laid by Siemens Brothers under a contract with the Mackay-Bennett Co., which, so far as we are aware, is the first instance in which American manufactured material has been used in any of the transatlantic lines. The average of all tests, 99.4 per cent. Matthiesen's standard, shows that a superior quality of metal was used. The wire actually shipped averaged 99.87 per cent., a figure seldom reached in so large a quantity. The same firm supplied the copper rods for 500 additional tons of conductor for the same cable, which was manufactured in England.

A TELEGRAM from New York to New Zealand traverses a length of line of 19,123 miles, nearly three-fourths of which is submarine cable. It has to be repeated or rewritten fifteen times. The longest cable is between America and Europe, say 2800 miles, and the longest land line is across Australia from Port Darwin to Adelaide, 2150 miles. When the Australian merchant finishes his day's work he can telegraph to London, knowing that the London merchant is beginning his day's work and will have all day to attend to it, and that he may expect a reply when he opens his own office again in the morning.

A SMALL central-station installation which exhibits some new features of interest is now in successful operation at Peterborough, N. H. The power is derived from turbines located about four miles

from the center of distribution, from which a 2000-volt alternator supplies current to large reducing transformers wound especially for the local distribution. This is laid out on the ordinary three-wire system, and enables lamps of either 52 or 104 volts to be used.

A WELL-KNOWN electrical engineer says: "I know of one electric street-railway in this country whose cars are always fresh, neat, and clean, and which has even gone to the expense of putting a clock in each car as well as a mirror at each end thereof. The result is that this road has gained a larger patronage in proportion to the number of inhabitants in the district served by it than any other road in the country; the stockholders are pleased with the road; the patrons are pleased with it; and the general manager does not have a fight on his hands every day of the week." This statement furnishes much food for thought.

IT is probable that Fifth avenue, New York, is now the finest example of an electrically illuminated thoroughfare in the world. At each cross-street corner is an ornamental iron post carrying two low-tension arc lamps of tasteful design, fed from the ordinary house-service mains of the Edison Illuminating Co., and another similar post is placed in the center of each block, making in all eighty lamps per mile. The effect is most artistic, brilliant, and beautiful. The original installation of the system was mentioned something over a year ago, in these notes, but more recently the number of lamps has been doubled and the effect greatly enhanced.

ONE of the best materials yet tried for underground conduits for electric wires is wood-fiber treated with an insulating and preservative compound, so as to form a dense, hard substance. The fiber is formed into tubes of five feet in length and of any diameter from one to twenty-four inches by an ingenious machine recently invented for the purpose. Couplings, fittings, and section-boxes are made of the material. The prepared wood is a perfect non-conductor of electricity and heat, and, when laid in the ground, is much more durable than iron, being unaffected by either acids or alkalies. One advantage, which will be appreciated by electricians, is that the material is easily cut by ordinary tools, so that joints or fittings can be inserted at any point where it is desired to connect a branch.

SEVERAL years ago an arc-lighting plant was installed at Oswego, N. Y., in which the dynamo was driven by a large turbine-wheel, controlled by an ordinary ball-governor. A considerable amount of other machinery was carried by the same wheel, which added to the unavoidable irregularity of the load. Much trouble was at first experienced from the burning-out of switches, lamps, dynamo-fields, and armatures; the cause of which was ultimately traced to the excessive speed attained by the turbine under a sudden diminution of load, before the governor had time to act. Acting upon the advice of an expert, a heavy fly-wheel was attached between the turbine and the dynamo, which had the effect of removing all the annoyances arising from the cause referred to.

THE most serious problem confronting the managers of the electric railway systems at the present time, and in the immediate future, is beyond question that of the destructive effects of the powerful electric currents used in that service upon the vast network of metallic pipes for the distribution of water, gas, and electric cables which lies beneath the surface of the ground in all our large cities. The first investigator who called attention to the seriousness and unsuspected extent of this danger was Mr. I. H. Farnham, of Boston, and the results of a long series of experiments and tests were given in an exhaustive paper read by him a few weeks since before the American Institute of Electrical Engineers. Specimens of corroded pipes of lead, cast-iron, and wrought iron were exhibited, and cases were mentioned of iron water-mains which had been almost completely destroyed by electrolysis within less than six

months. Some of the worst cases of corrosion which have been discovered in Boston were found to have been due to a difference of potential of only 1½ volts, and it has been experimentally determined that a difference of so little as 1/100 volt is quite sufficient to produce the action, either upon lead or iron. This circumstance indicates that the evil cannot be overcome by the application of the often-proposed remedy of increasing the conducting power of the return circuit by the aid of special conductors. Mr. Farnham concludes that while very much may be done to diminish the intensity of the action, its effectual elimination is still an unsolved problem.

A STATISTICAL table of the electric railways now in operation in Europe has recently been published, from which it appears that at present Germany occupies the leading position in this field. The figures of length of track and power used are given as follows: Germany, 102 kilometers and 2934 kilowatts; England, 71.4 kilometers and 2993 kilowatts; France, 414 and 1796; Austria-Hungary, 33 4 and 1115; Switzerland, 23.6 and 706. The total number of lines is forty-three, having an aggregate length of 305 kilometers; total station-capacity 10,654 kilowatts; number of motors and motor-cars 538; number of trail-cars 151. The overhead system of distribution is much more largely used than any other, and a considerable number of the plants are of American construction. There are about twenty-four additional lines in progress which are expected to be running before the close of the year.

THE general conclusions reached by Mr. Farnham may be summarized by saying that all single-trolley electric-railway systems employing the rails as a portion of the circuit inevitably give rise to the electrolytic corrosion of buried pipes in their immediate vicinity; a fraction of a volt in difference of potential between a metallic pipe and the damp earth in contact with it is sufficient to induce this action; the provision of a return conductor, even when equal in conductivity to the outgoing line, is without avail to wholly prevent damage to pipes; it has been found advisable to connect the positive rather than the negative pole of the dynamo to the trolley wires; and, finally, a conductor of large capacity extending from the grounded end of the dynamo, entirely through the district affected, and connected every few hundred feet to such pipes as are in danger, will usually secure their protection. Connections between the pipes and the rails or the return conductors at points outside the affected district should be carefully avoided.

A VERY interesting example of electrical power-transmission has been installed in connection with a large cotton-mill recently started by New England capitalists at Columbia, S. C. The length of line being only 800 feet, and the head of water but 25 feet, two special slow-speed tri-phase generators, of 500 kilowatts capacity each, were specially designed for the service. In order to gain the advantage of direct coupling to the turbines, these were necessarily made of unusual size and weight. The armatures are of the iron-clad type, and are ten feet in diameter. The speed is 108 revolutions per minute, giving a frequency of alternation of 36 per minute. Two pairs of 48-inch horizontal turbines furnish the motive-power. The conductors are carried underground in a plank conduit. The machinery of the mill is driven by seventeen 65-horse-power motors, hung overhead, and driving separate sections of line-shafting by direct belting. The motors are speeded at 535 revolutions per minute, and vary in speed less than 2 per cent. between load and no load. In addition to the motors, several hundred incandescent lamps will be operated within and about the mill. It will be observed that this is one of the first instances in practice of the application of power distribution or subdivision in textile manufacturing, and the results of this undertaking may not unlikely mark the beginning of a complete revolution in the existing practice in that department of mechanics.

ANOTHER phase of this problem, of somewhat startling significance, is pointed out

by H. C. Cushing, Jr., in a recent communication to the *Electrical Engineer*. Mr. Cushing states that he has found instances in which a large difference of potential existed between two pipes entering the basement of a city building at points less than a foot apart. In one instance, with a piece of hoop-iron, an arc was drawn between two such pipes, by which a bunch of waste was ignited. In another instance, two pipes were so close together that the movement of the elevator caused sufficient vibration to alternately bring them into contact and separate them, causing a small electric arc every time the contact was interrupted. If this had not been discovered, a hole would ultimately have been made in the gas-pipe, and the escaping gas would have been ignited by the arc with the usual disastrous results. These dangers are enormously increased by the fact that many persons have discovered that they can secure an abundant supply of electricity free of expense for operating bells, gas-lighters, and even small motors, by simply attaching their wires to the gas- and water-pipes on their own premises. An increase in the difference of potential from any accidental cause is of course liable to convert such an arrangement into a most dangerous incendiary device. No doubt many of the fires which originate from unknown or at least unexplained causes are in fact due to some such condition of affairs as that pointed out by Mr. Cushing.

THE Postal Telegraph Cable Co. has fitly celebrated the semi-centennial anniversary of the opening of the first telegraph line between Washington and Baltimore, which took place in May, 1844, by taking possession of the magnificent building which has been constructed especially for its occupancy, on Broadway, New York city. The building is fourteen stories high, the basement and first floor, as well as the eleventh, twelfth, and thirteenth, being devoted to the uses of the telegraph company. The new building contains many novel features, some of which mark a notable advance in the administrative details of the telegraphic service. The electric current for operating the wires is derived from machines called dynamotors, which are in fact a combined dynamo and motor. They are driven by currents derived from the ordinary incandescent lighting street-mains and may be made to give out currents of any voltage required in the telegraphic service. The main operating-room is 70 by 156 feet in area and 18 feet high, and will accommodate over 300 operators. An interesting feature is that nearly all the operators of this company have accustomed themselves to copy received messages upon the typewriter, which has proved to be much more expeditious and accurate than the old method.

IN view of the reported decision to install a section of the Siemens electric conduit railway in the city of New York, the results of the operation of the Budapest system, to which we have heretofore called attention in these notes, is of interest. Twelve million passengers were carried in 1893; the receipts were about $500,000, permitting the payment of 8 per cent. upon a capital of $2,000,000. More than 100 cars are now running in Budapest.

IN the Ponemah mills, at Taftville, near Norwich, Conn., a different plan has been adopted from that just described. Two Corliss engines have been replaced by two tri-phase synchronous self-starting motors, of about 250-horse-power each, leaving the belting and shafting of the mill practically unchanged. These are driven from generators installed in the basement of the old Sprague mill at Baltic, 4½ miles distant. The generators and the motors are alike. The former are belted to a main shaft driven by three pairs of 42-inch and one pair of 27-inch turbines, under 32 feet head. The Norwich street-railway system is operated by a railway generator located at the Ponemah mill, which is belted to one of the tri-phase motors above described. The manufacture carried on is that of fine cotton goods.

ARCHITECTURE

Conducted by Barr Ferree.

MR. THOMAS HASTINGS is the only gentleman we know who lives in the fifteenth century. That he lives in the era named is, we gather from the interesting article he contributed to *Harper's Magazine* for May, his own belief, and it would be unfair not to accept his opinion on a matter that so closely concerns himself. Mr. Hastings needs no introduction as a supporter of the Renaissance. He has shown us, in a thoroughly masterly way, just what may be done with it under certain conditions, and, with equal directness, has shown us just what not to do with it. He speaks, therefore, with the power of authority, and his paper on "The Relations of Life to Style in Architecture" not only is interesting in itself but is entitled to the most respectful consideration. Mr. Hastings's position is that we must "recognize our true historic position and the principles of continuity in history," and, therefore, "we should study and develop the Renaissance and adapt it to our modern conditions and wants, so that future generations can see that it has truly interpreted our life." We should think that the effect that architecture might have on the living generation would be more important than its esthetic effect upon generations to come. But this is not the point of the discussion, which is our "historic" position in regard to the architecture of the Renaissance. By the Renaissance Mr. Hastings means all architecture done in the last four hundred years, "whether belonging to the period of Francis I, Henry IV, Louis XIV, or the Empire." It is impossible to deny the breadth of this definition, for it includes everything from the time of Francis I, though in it Mr. Hastings shows his French training, since it ignores the beginnings of the Renaissance in Italy and treats it as a purely French movement. As the spread of the Renaissance in France was chiefly a matter of fashion, the cultivation of a new taste by the French sovereign and his court on their return from the Italian wars, we are astonished that a writer who makes so much of his historical position should ignore this fact. Renaissance architecture, we are given to understand, survived almost up to the present time, when revivals of medievalism set in. In other words, we presume, a style that survived the artistic depths of the seventeenth and eighteenth centuries, that lived brightly and merrily in the early years of the nineteenth, came to a sudden and untimely end because, forsooth, a few architects undertook the so-called Victorian Gothic. It is always the unexpected that happens, and it is not unnatural, perhaps, that the lusty style that withstood so much should at last succumb to the most trifling ailment.

MR. HASTINGS'S paper proceeds on the assumption that all architectural styles are dead save the Renaissance. That is still alive, or, if dead, is so recently deceased that it is possible to resurrect the corpse without great exertion. If this is so it must be a matter of belief, since the Renaissance architecture of the fifteenth and sixteenth centuries, to go back no further, is surely as dead as Tiglath-Pileser II. The architecture of that time was succeeded by feeble imitations, which simply announced the end of the former epoch and did not in the least proclaim its vitality. And there have been successions of styles, real and imaginary, since then, the present Renaissance revival being simply a fad that differs only from other fads in being conducted and practised with more earnestness. The present age is wholly different from any any previous age, though Mr. Hastings does not appear to think so. It is an age of science, of mechanics, of engineering, of money-getting and money-making on a new and improved fashion, the like of which was

never seen before. These are the things that make our life, and if style is the reflection of life in architecture they must appear in our buildings, as other life-elements have appeared in the buildings of other times and peoples. Mr. Hastings would have no reproductions of medievalism in this modern day; but he cannot have too many reproductions of the Renaissance. He tells us the Victorian Gothic failed because the life of the time was not Gothic; he avers that the Renaissance will succeed because we live the same life. Yet he must know that every time he looks out of his office-windows at the cable cars he is looking upon a phase of life quite different from anything known before. But however one may differ with Mr. Hastings as to his historic position, as to his views of life, as to his own favorite style of architecture, it is impossible not to feel his earnestness, not to realize that he thoroughly means what he says and speaks from profound conviction. The Renaissance with him, for this day, is neither a fashion nor a fad, but a stern, living reality. He is not thrusting his personal likes and dislikes upon the world in this paper, but explaining what he believes and why he believes it. And this he does in so delightful a fashion that one almost wishes one could agree with him in the positions which he maintains.

NOT very long ago a certain architect whose design for a high office-building was passed over by a building committee in a notable competition—though a very good design, it may be remarked—got up in public meeting, a few days after the announcement of his lack of preferment was made known, and remarked that it would be better to build no more high buildings in the city of New York. As the author of this remark had, in the course of an extended practice, erected many high buildings—some, it must be confessed, quite inferior to the aforementioned design that failed of acceptance, though not of excellence—his unexpected utterance attracted an attention quite disproportionate to its importance. There may have been, and probably was, an accidental sequence in these two things, but such is the origin of an outcry against high office-buildings that has come from the mouths of many New York architects. The self-sacrifice involved in this campaign is enormous. High office-buildings are the most lucrative form of work that now comes into architects' offices; if a law is passed forbidding them the architects will be the first to suffer. Yet a number of these men are now posing as very noble advocates of a measure affecting the health, comfort, and safety of the metropolis of America. Perhaps there is some truth in what they say. The modern high office-building is a thing of unknown horrors. Though methods of construction are improving each day, though new devices are constantly being invented that will render them safer and more profitable, no one will venture to say just what would happen in case of fire. It is to be hoped no one ever will know, and that no great calamity will visit them or misfortune happen to them. It is an undeniable fact that a narrow street full of very high buildings would be a most dreadful thing. On the other hand, it ill becomes the designers of high buildings that ought not to be seen under any circumstances, to agitate for wider thoroughfares, or take any other steps which will make them more visible. The narrow streets of New York, darkened as they already are by some high buildings, have been blessings in disguise, since they have effectively prevented the hideousness of many lofty buildings from being seen. The question of unhealthiness is also not wholly without foundation, but every engineer will admit that the science of ventilation is still largely in its infancy, and it is an unquestioned fact that many business buildings not noted for their altitude are conspicuously bad and dangerous places to work in. It cannot be denied, further, that rows of high buildings will darken rows of other high buildings placed on the opposite side of the street. But the moment this becomes apparent the continued erection of these structures must receive a set-back. Real-estate owners cannot go on erecting structures that have a damaging effect upon adjacent buildings.

AND the real-estate interests in New York, and in every large city, are more powerful than the utmost volume of architectural opinion. The present high values placed upon commercial property in land are very largely due to the ability to construct high buildings upon small sites that practically increase the renting value of the land. Remove the ability to do this and a great shrinkage immediately occurs in the value of land not already occupied by high buildings, with a consequent artificial increase in the value of property of that description. The latter change is, perhaps, not to be deplored, since every property-owner is anxious for his property to increase in value, whatever the cause may be. But certainly any movement that looks to the lessening of real-estate values by legislation will meet with powerful antagonists. The self-sacrificing labors of the architects will be as naught. They will have ventilated a hasty opinion, since only opinions are available against the merits of high buildings; there are no facts at hand. They will have posed as public philanthropists. They will have placed themselves against the wishes of their most profitable clients. Apart from these results, it is difficult to see what will happen from an agitation against the high building. Now if, instead of bringing up this entirely new question, the architects of New York were to argue out the question of the architectural expression of the modern high commercial building, the greatest good might result, not only to themselves but to the public at large. The problem of design in the high building is very largely the same in a great many instances. There is no reason at all in the nature of the case why certain general principles should not be formulated and the problem worked out on a single definite line. Even if the mode to be followed should not be the best it would at least be a step in advance in suggesting work in one direction, and when a number of architects get down to that way of doing things excellent results are to be expected. By all means, gentlemen of the architectural profession, consider the question of the high building, but keep within your own proper limits.

THE American Institute of Architects has appointed a committee to draw up a code of regulations concerning competitions, and suggestions are invited from all architects upon that subject. So much space has been given to this topic in these pages that it seems scarcely necessary to refer to it again, but the appointment of this committee is a sign of the times that cannot well be overlooked. Competitions have now become so important a feature of the architect's work that it is entirely incumbent upon the most important architectural body in America to decide how they shall be conducted. This is the very point on which the greatest divergence of opinion exists, and it is to be hoped that the Institute will succeed in devising a code that will meet with the entire approval of the profession. It would be a pity if this committee should not find it within its scope to determine the advisability of competitions at all. These trials of ability are so common that the busy architect must devote a great deal of his time to competitive work if he would keep his office full. It seems scarcely possible that such a condition of affairs should be permanent. The burden it entails upon architects must, before long, become so great that none but the very youngest architects, who have nothing under the sun to do, can afford to go into them. Whether, when this becomes reality, we shall see the work leaving the offices of the older men for the younger, remains to be seen. Meanwhile it appears eminently proper that architects should most carefully consider the ultimate end of the competition craze. That it is such no unbiassed man can deny, and we do not see how architects can get away from the appalling situation they may find themselves in when the present movement is pushed to its furthest logical development. Before drafting any rules for the guidance of competitions, it would seem to be the first business of the committee to determine whether competitions are desirable, whether the work they cause the architect is compensated for, whether the mental strain, the raising of hopes, the dashing of expectations, the dreams of success, the sorrow of

failure, the wire-pulling, the exerting of influence, the personal equation, the obtaining of votes, the hundred-and-one elements which help to decide a competition (to say nothing of the relative merits of any individual drawing);—it would be well to decide if all this pays and if it is desirable to bolster up the system that rests on such a multitudinous basis. Then if the committee will give the reasons why competitions are desirable or undesirable we will have a document that may be looked upon as a standard, and which will serve as the basis of later regulation and arrangement. Otherwise we do not see how the committee can avoid the summarizing of the whole subject in a few brief rules, very much like the following:

Rule 1.—No building shall be erected unless the design shall be chosen by competition.

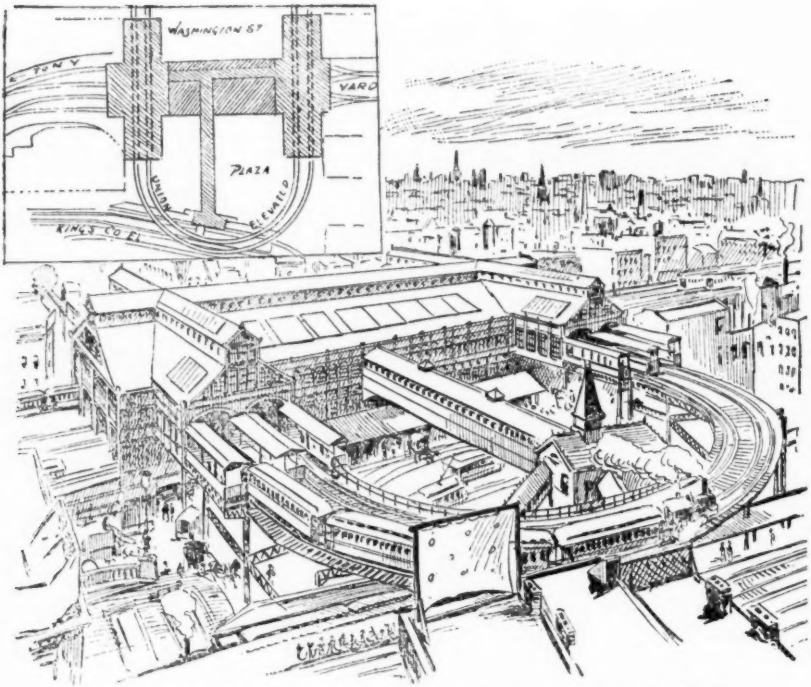
Rule 2.—No competition shall be held unless all the competitors are duly compensated for their labor.

Rule 3.—Uncompensated competitors shall be ruled out.

Rule 4.—Every design submitted by a paid competitor shall be declared the best and chosen for erection.

Unless rules somewhat on these lines are formulated it will be impossible to avoid the heartburnings, the discontent, the dissatisfaction, the disgust which is rapidly souring the tempers of very good architects through the competitive system. And an architect with a soured temper is no better off than a man with a balky horse. We must admit we have no idea how such rules would operate in practice; we are not concerned with that. Our position is that, as competitions were invented by the architect for his own personal advantage, nothing short of such rules will be acceptable.

THE picture on the following page is not a view in Philadelphia, or in Nankin, or in Timbuctoo. It is neither a caricature nor a glimpse of architecture a hundred years hence. It is simply a very rough sketch of the proposed new terminal-station in the city of Brooklyn for the New York and Brooklyn bridge. It is a scheme the like of which cannot be duplicated in the civilized world, and, as it is actually proposed to carry out this work on the lines here illustrated, Brooklyn will soon be possessed of the greatest architectural wonder of the globe. Heretofore Brooklyn has chiefly been famous as the scene of the oratorial contortions of pulpit orators; when the Bridge Station is finished it will possess an inextinguishable curiosity that will permanently eclipse all other attractions, actual or to come. Imagine, if you can, a city paying out $2,000,000 of good solid public money for the purchase and creation of a public square and the laying out of a fine, broad avenue, and then permitting certain private personages, who have contributed nothing at all to the cost of these improvements, to deliberately seize this public property for their own individual personal aggrandizement. Yet this is just what has been done in Brooklyn in the year of grace 1893-94, and the general effect of this operation is shown in the sketch. In the background rises the huge bulk of the terminal-station proper—a vast ugly bare frame, designed without the smallest pretense of architectural discernment, planned without regard to the convenience of passengers; a structure almost shapeless in its hideousness; cold, stupid, horrible, inane. From its two ends emerge the ends of a huge semicircular encumbrance, lifted high up in the air where it may be seen by all men, and having for its single use the convenience of an elevated railroad corporation that has been shrewd enough to take public land for its own convenience. This semilunar structure entirely surrounds the costly plaza paid for by the city of Brooklyn, which thus becomes of no value at all. But in case there should be doubt, its ruin is emphasized by a *pons asinorum* that shoots suddenly across the center to suit the convenience of another elevated railroad. It is a most serious public misfortune that public taste and enterprise in Brooklyn are at so low an ebb that the possibility of obtaining a really noble entrance to that most noble of New York structures, the great East-river bridge, should have been so wantonly ignored.



BROOKLYN PLAZA, AS IT WILL APPEAR AFTER THE RAILROADS ARE IN POSSESSION.
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It is a scandal that public officials should be retained in salaried positions at the public's expense who could think of such a preposterous plan. And more than all it is an outrage that, with so faulty a plan, the utmost effort should not have been made to have clothed it as decently and as orderly as possible. But there has been no attempt to do this. The plans and elevations of the station are miracles of incompetency and absurdity. Engineering never so boldly confessed its own weakness, nor has the engineer more freely admitted his inability to cope with questions that belong quite as much to the architect as to himself, if not more.

WE are pained and surprised to learn that, notwithstanding its eagerness to obtain recruits, the Society of Beaux-Arts Architects of New York has as yet formulated no initiatory ceremonies, whereby the self-consecrated candidate for Frenchite orders is set apart from the ordinary herd of mankind. This is a most serious omission, and we trust that it will soon be remedied. The Frenchite architect is the salt of the earth, and it is entirely becoming that he should be formally marked as belonging to that consecrated class. Pending any action by the Society on this point, which we should have supposed would be one of the first things to command its attention, we venture to outline a little ritual of our own as eminently suitable for the solemn occasion: The members, clad in genuine École blouses heavily stained with genuine Parisian ink, will receive the victim (this, being a shorter word than candidate, is used as more convenient; no suggestions intended). Each member will be armed with the sacred T-square and provided with his self-blowing horn. The victim, clad in his ordinary garments, will be introduced in silence. Then, while his outer upper garment is

being removed, the Society will sing the consecrating hymn "To Paris" (pronunciation *à la française*, if you please). The president will then, by means of a speech in the purest of Écolian French (of which the victim will understand not a word), seek to impress upon the young man the solemnity of the occasion, the importance of the Society, the sacred nature of its work, and other notable questions, casually alluding to the duties that will await the victim in Paris. The chief feature of the "effacement" ceremony that will follow this will consist in injecting a special brand of Frenchite Keeley-cure into his right arm, which will have the double advantage of causing the victim to hate all manner of strange thing in Paris, save Frenchite modes, and will render his right hand incapable of drawing any save genuine Frenchite designs. After this will come the clothing of the candidate with a snow-white blouse, which is to be worn constantly when in Paris, and the presentation of the self-blowing horn, warranted to take up the story of its owner's greatness should he, by any means, cease speaking of it himself. Various other details may be added according to the taste of those most concerned. We should think that these might form the essentials of the ritual, and, in an organization composed of so many skilled designers, it would be possible to embroider a positively beautiful formula upon it. An important feature would be the presentation, by the vice-president, of his famous ethical work "On the method of designing in the ancient Italian style by means of deceased architects."

THE *Architectural Review*, we understand, reaches a refined, cultivated, cultured circle of readers. Trustworthy as this statement probably is, we doubt if its readers can long stand the strain put upon them by some of the topics suggested in its editorial pages. In a recent number it brings up before its R. C. C. Circle a profound problem concerning the seriousness of this Department. "We are somewhat doubtful," it writes in sonorous phrases, "if the Architectural Department of THE ENGINEERING MAGAZINE is to be taken seriously." This truly is a masterful problem, and, if the editor himself cannot understand it, we do not see how his readers are to make it out. Still we suppose it is natural that, meeting an apparently unanswerable problem, one should seek a solution at every available source, and we trust that the *Review* will lay before us the results of its appeals for information. Of course there can be but one true answer to such a question, and we are amazed that the *Architectural Review* should have any doubts on the subject. We should have no objections to answering this problem ourselves in its columns, but we really must decline to burden our own pages with a topic on which we hope our readers need no light. We think, however, that we may be permitted to state that our views of current architectural conditions are necessarily somewhat limited by the horizon of New York. The architects we meet, the clients we hear of, the conditions we are most familiar with, are those of New York. It may be different in a great center like Boston. We do not know Boston as we should, though we must leave the *Review* to decide if what is our loss is Boston's gain. Clients and architects may be different there. It is possible that architects, in their eagerness to serve their clients, may despatch their own carriages to bring them to their doors. Such a custom is, we are sure, unknown in New York. But it may be the custom in Boston. We repeat this is our loss; apparently there are advantages to be gained in surveying architecture from the neighborhood of Boston harbor that are not known to those whose horizons are limited by the contracted area of New York, and the small narrowed life contained therein. We are astonished that, with its wide, glorious, free vantage ground, with its enviable point of view, and its unsurpassed opportunities, the *Architectural Review* should have deemed it necessary to open a department in its columns especially consecrated to ourselves. Surely there are mightier problems in architecture to discuss than this, greater truths to expound than our conviction of error, grander work to do than expressing surprise at what we may choose to say.

Conducted by Thomas L. Greene.

THE complications which have arisen in the affairs of those railways which are in the hands of receivers, and the conflicting statements put forth by committees representing the various issues of bonds and stocks, have brought into clearer relief the necessity of possessing full and accurate information about the affairs of all corporations. Bookkeeping, it may be observed, is not an exact science. Its *purpose* is to express the conception held by those who control the entries. There is no miracle-working power in the art of accounting which can automatically disclose a danger-signal. Just as two persons in describing an incident will use language which may state the facts correctly, but which will give a different coloring to the occurrence according to the interests or prejudices of each observer, so bookkeeping can only reveal the views, whether reckless or conservative, which the officers of a corporation may hold regarding certain business facts; for illustration, much of the modern system of corporation finance depends upon the distinction between charges to income and charges to capital. Charges to income affect the earning power of the company and may alter the amount of bond interest or dividends to be paid for the year. It is natural, therefore, that the officers of a corporation who are anxious to make a record for successful management of the property over which they have been put in charge should decide a doubtful question of expense in favor of a debit to the capital rather than to the income account; and, indeed, with the best of intentions it is often very difficult to draw the line. Unscrupulous men may take advantage of this general doubt and so make up the accounts of a railway as to show and to pay large profits, while the real fact may be that unearned money is being distributed to shareholders with the result of forcing bankruptcy at the first pressure of hard times. The same remarks may be made about the need of allowing for depreciation and renewal of plant or equipment.

THERE is all the more necessity, then, of furnishing to the public statements in full detail of all the operations of railway and other corporations in order that bond- and stock-holders may form a judgment of the real condition and earning power of their property, independent of all opinion of their managers. Corporation reports which show only the aggregate figures of earnings and expenses are useless to any investor who wishes to have some knowledge of the company in which he is interested. We are living in an era of corporations. The corporationizing of our carrying and manufacturing industries has proceeded rapidly of late, and when better times return again we shall undoubtedly see other companies formed. So long as a business is conducted by a partnership the public have no interest in its private affairs. How the partners keep their books is a matter of no concern to others. This consideration is subject to slight modification when such a partnership is turned into a corporation whose shares are all held by the late partners and not offered to the public. In such cases the public have a right to ask only for such information as is commensurate with the advantages of the corporate form granted to the partnership by the state. That is to say, in return for the freedom from personal liability for corporation debts, it is right that the corporation officers should make such statements of their affairs as shall give the creditors a fair notion of the financial standing of the company to which they are loaning money or selling goods on credit. This statement, however, need not go to the length

of declaring the profitableness of any industrial or trading concern, since with that the creditors and the public are but remotely concerned.

THE case is at once altered, however, when the bonds and shares of such a corporation are offered for sale publicly. Shareholders of a company, whether a railroad or a manufacturing corporation, are really partners in the enterprise and are entitled to know the true condition of their property. The moment a man is asked to invest his money in a business, that moment he is justified in demanding full particulars. It is true that in the past many have bought bonds and shares with little or no inquiry, but that state of things is passing away. Banking-houses which have a reputation to lose are no longer taking the chance of destroying their business by recommending investments which are filled only with air promise-crammed. Particularly is this truth brought out by the conflicting plans for reorganization of insolvent companies put forth of late. Where a stockholder is asked to pay an assessment upon his shares, or a bondholder to scale down his interest and principal, when perhaps he had expected golden returns from his investment, such an investor is apt to ask questions regarding his corporation which he ought to have asked long ago. But the lesson, though bitter, is likely to be thorough, and thus corporations which in the future shall decline to give full information regarding their affairs will be made to feel the effects of their bad policy by a lower range of quotations upon their securities and by restricted markets.

THE arguments for full corporation reports are, in the case of railways, greatly strengthened by the semi-public position of those companies. Nothing is better settled in our law than that in return for privileges like that of eminent domain our common carriers owe duties to the shipping and traveling public which must be fulfilled. If these carriers are to be made subject to restricted or regulative legislation of any kind whatever, it is of the first importance that this governmental control by legislation should be based upon accurate knowledge. The work of the statistician of the interstate commerce commission, though subject to criticism in part, has been of great value in forcing upon our railways the necessity of publicity in their accounts, and of accuracy and uniformity in the methods of accounting employed. Reforms of this character do not go backward, and we may expect hereafter better information on the earnings and work of our corporations.

THERE has been lately discussion about the affairs of a prominent company which involved some of the most serious questions in our corporation finance. The Delaware and Hudson Canal Company is an old corporation which was formed originally to own and to work some anthracite-coal lands in Pennsylvania, including a canal to the Hudson river as a water outlet for the coal. In course of time railroads were added by lease or ownership, until now the railway department of this company is as important as the mining department, while at the same time furnishing an outlet for the coal. The Delaware and Hudson has paid regular dividends of 7 per cent. Some $5,000,000 of bonds maturing next October, it was proposed to issue stock to this amount at par to the present stockholders to take up these bonds. As the shares are selling at 140 or more, and as there is no doubt in the mind of the public of the continuance of this rate of dividend, the proposition involved the granting of a bonus of $40 to each subscriber of a new share. Not content with this premium, a minority of the board of directors of this company advocated the issuing of this new stock to old shareholders at 75, the plan being to take the other 25 per cent. from the treasury of the company. To this scheme the majority were strenuously opposed, and by appeals to the stockholders these latter gentlemen secured proxies enough to elect their own board of directors and carry out their plan of issuing the new stock at not less than par. The Delaware and Hudson Company carries in its balance-sheet an

item of surplus dividend fund amounting to $7,000,000, and it was from this supposed fund that the minority directors proposed to take the cash necessary to retire the bonds. But this large sum is shown by the same balance-sheet not to exist in cash but to have been invested in assets of the company. With few exceptions these assets, while important to the company as a miner and carrier of coal, have no other intrinsic value; thus the canal, worthless for any purpose except that of transporting coal, is carried on the books at a valuation of $6,000,000. The New York and Canada railroad, a branch of the system which does earn interest on the outstanding bonds, is put down at $4,500,000. The significance of these figures will be appreciated when the business of the company as a producer of anthracite is considered. The coal in the lands owned by the company, according to a committee's report, will be exhausted in sixty years. Practical coal-men familiar with the territory do not think that the Delaware and Hudson supply will last as long as that, while no doubt the increasing difficulties of mining will make themselves felt in from twenty to thirty years. The $30,000,000 of capital stock of this company is invested in such assets as have already been mentioned, besides coal-lands and colliery improvements. Nearly all of these assets will become valueless when the coal is exhausted. What then should be the policy of a corporation whose end is, as corporations go, not very far off? In the light of the facts mentioned, not only should the company not issue new stock at 75, but the issue at 100 is of doubtful expediency. Ten-year bonds at 4 per cent. could have been sold to take up the old-7-per cent. bonds, and the 3 per cent. in interest saved could have been held as a fund for the retirement of the bonds at maturity: or, if the company wished to adopt at once a very conservative course, they could establish a sinking fund of 10 or 15 cents per ton on all coal mined: the money to be taken from the coal receipts each year and held as an offset to the gradual depreciation of the property. Such a sum per ton would just about cancel the capital stock at the exhaustion of the coal-lands. But present stockholders can scarcely be expected to take such a conservative view of their affairs. The motto of present holders is always "After us the deluge," even though the last holder should eventually lose the whole. But at least public opinion should keep corporations of this character from unusually reckless financiering.

IT has been suggested in recent numbers of this Magazine that there was still a large field for engineers in the railway business, although it was remarked that our younger men could profitably direct their attention to those things of which the railways were in immediate need. This remark applies to other departments besides those of engineering proper. For illustration, it is confessed by all operating offices that the American system of collecting tickets on passenger trains is loose and uneconomical to the highest degree. This fact is proved, if proof be needed, by the efforts made at times to discover how things are running, and whether conductors are honest, by means of spies. That the system of employing spotters is a very crude way of attempting to cure the evil needs no argument. It substitutes spasmodic examination instead of a system, it gives the honest conductor very little chance to defend himself against a mistake, and it does not do much toward permanently curing the practice indulged in by unscrupulous passengers of dodging or cheating the station-agent or conductor. The compulsory showing of tickets at a station has done much, but that manifestly cannot cover the whole case. The Chicago and Alton railroad is trying an experiment on a small scale which will be watched with interest by all concerned with the matter of passenger revenue. In effect it is a system of turnstiles at particular points. Indeed, it has been suggested by some of our older officers that revolving gates for both ingress and egress should be established at every station, by which means an automatic register could be had of all travelers getting on and off the trains at each station. If such a record could be kept for a stated

time it would form an accurate statistical basis for estimating the passenger business at one station and between all other stations. Then if tickets and cash did not come up to the number of passengers thus to be accounted for an investigation could be intelligently begun and the error or cheating quickly found. The main difficulty in such a scheme would not be so much the first cost—although that might be considerable—but would be rather the opposition sure to be developed on the part of the traveling public. Passengers will wait until the last moment before trying to catch a train, and if a number lost their train because of getting behind a large crowd, which the turnstile would allow to approach the train only one at a time, there would be such loud complaint that the railway officers would be forced to take notice of it. Large numbers of turnstiles at all stations would be out of the question, besides being very expensive. How, then, shall this problem of ascertaining the number of passengers and their journeys on our American railways be solved? Fame and a fortune awaits the civil or mechanical engineer who shall invent a system or an apparatus which shall yield such information as will enable a reform to be carried out.

BUT for the hard times we might already have seen an evolution in the business of carrying passengers upon the Great Lakes in connection with the railways. The Great Northern, under designs of its president, Mr. James J. Hill, has already constructed one steamer wholly and another partly. These steamers are for passengers only and are intended to make remarkably quick runs between Buffalo and Duluth, connecting at the latter point with the Great Northern system. There are now some fair passenger boats upon the lakes, and the trip is occasionally taken by tourists, but these boats also carry freight and are hindered in speed and accommodations by that fact. Mr. Hill's intention was to put on the lakes boats which in speed and comfort would rival the river and Sound boats running out of New York. By carrying first-class passengers without encumbering the boats with freight, President Hill believes that he could induce more tourists and capitalists to take the trip via the lakes and over his road; while emigrants could be carried on the same steamers who would help settle the vacant lands of the Northwest. Such a plan once put into effect might have important consequences upon the carriage of railway passengers on the lakes.

IN view of the timely note sounded in the May number of this Magazine, that American manufacturers must seek foreign trade, it is well to refer to a very important publication on the South American railways prepared by the Oriental Republic of Uruguay as a contribution to the World's Fair at Chicago. Those who are or should be interested in our trade with South America would do well to read first of all the admirable and comprehensive review of the general conditions of the railways in South America by Mr. Courtenay de Kalb, in the April number of this Magazine. This Uruguayan treatise contains a mass of most useful information and statistics bearing upon the same subject. The publication gives the details of the railway laws of Uruguay and the other countries, the government requirements, methods of tender, the concessions of the government and the like. It also gives tables of gradients, mileage of the railways, and distances between stations. A good condensed description is given of the nature of the soil and the kind of roadbed adopted as the standard, together with drawings of buildings and bridges as well as cars, sections of banks and cuttings. Tunnels are described, and also the workshops with their fittings. Mr. DeKalb said in his article that American rolling-stock is superior to any other for use on the South American railroads, and that European manufacturers modelled their equipments after United States patterns. In the Uruguayan treatise tables are given describing the equipment of these South American railways in full detail, giving type, number of cars, tare, load, class, name of maker, and year built for all the principal companies. Comparatively few American names appear

in the tables as manufacturers of either locomotives or cars, but the description of this equipment is more full and accurate than can be found elsewhere. Don Juan José Castro, the Montevidian civil engineer to whom the Uruguayan government entrusted the compilation of this work, gives also tables showing the statistics of operation of these railways, the tons of different commodities carried, the train-miles run, the number of passengers, and other like figures. Good accounts are given of the railway systems of Uruguay, Argentine, Brazil, Chili, Bolivia, and Peru. The author recapitulates at some length the story of the surveys made for the Intercontinental railway, which some day may connect the United States with these South American countries. A good deal of space is given to the project called the Interoceanic railway, a line which Don Castro thinks would be commercially successful if built from Pernambuco, Brazil, down the coast through Rio Janeiro and Montevidio to Buenos Ayres, and thence westward over the trunk lines now building to Valparaiso. The tables quoted in the treatise show a theoretical saving in time and money over the all-water route from Europe to the River Plate cities.

The treatise gives valuable information on subjects connected with the commerce of South America. Through exceptional means of information, with careful estimates where accurate statistics were wanting, a valuable series of tables is printed giving the population of South America by countries and by provinces. Thus we find that the total population of South America in 1893 was between 39,000,000 and 40,000,000 of souls. Of the 15,350,000 inhabitants of Brazil, 14,836,179 persons lived in the states bordering on the Atlantic ocean. The mileage of railways per kilometer and per inhabitant are given and compared with similar statistics of the United States, the argument being that increase of railways would bring increase of population and business in South America as it has in the United States.

Finally, and very properly, the treatise shows modestly but clearly the important place which Uruguay must hold in any extension of the railway system in South America. The great drawback to such extension is the extreme diversity of the gages of the railways now built, for Mr. DeKalb is unquestionably right in stating that systems of railways will pay in South America where isolated lines will not. Don Castro takes pardonable pride in quoting figures of exports and imports per inhabitant of all the South American countries, Uruguay standing at the head of the list. A comprehensive review of the cost of the South American railways by countries closes the book. By this table, Peru has paid most dearly for its railways, owing to the exceptional character of the country. A fact in this connection of interest is that the railway projected by Meiggs, in a distance of 200 kilometers rises to a height of 4779 meters, the highest in the world, Mt. Blanc itself being but 30 meters higher. Brazil has constructed its railways at the smallest cost per mile, partly because the narrow gage predominates in that country. The author believes that American practice in construction and in operation should be followed in the South American countries, and that our policy is the only one which will induce the building of railways sufficiently to develop business and commerce in the southern hemisphere without too much burden upon the countries at the outset. To those interested in railway building, equipment, and supplies, this publication by the government of Uruguay will furnish detailed information about South America not otherwise easily available.

THE Pennsylvania Railroad Co. has issued a handsome catalogue of its admirable World's Fair exhibit. It contains a plan of the exhibit and two half-tones, one presenting a front view of the company's exhibition building and the other an end view of the building, with the "John Bull," one of the Krupp gun-carriages, and the bridge crossing the tracks.

MINING AND METALLURGY

Conducted by Albert Williams, Jr.

IN some of the older metallurgical treatises on steel, and also in some of the more complete of the recent ones, reference is made to the effects brought about by the introduction of small quantities of silver into the metal. Experiments had been occasionally made with silver-steel alloys, and the evidence seemed to show that silver improved the metal for certain purposes. This has always been regarded as a mere matter of curiosity in metallurgy, because the high price of silver would prevent its use in any quantity, however small in percentage, that could be shown to be effective. Some persons have suggested, as an explanation of the superior qualities claimed for certain iron and steel made in the Rocky-mountain region, the presence of silver derived from the ores. It is well known that small quantities of silver do exist in these ores, but the quantity is absurdly insufficient to give perceptible results. A few ounces per ton of ore may make quite a showing in values, but when reduced to percentages become insignificant. But now the suggestion is made, half in joke, half in earnest, that a possible extension of the use of silver may be found in this direction, and thus help out the painfully depressed silver market. The proposition is hardly feasible, taking as admitted the beneficial effects of the combination. One per cent. of silver would mean about 20 pounds per ton of steel, or say, at ruling prices, about $150 to $175 a ton in addition to normal cost. Less than one-half of 1 per cent. would hardly be noticeable in effect, if at all, but one-half of 1 per cent. would cost about $75 or $87.50 extra. The term "silver steel," frequently used, is of course only a trade-name for a certain brand of cutlery-steel.

THE cause of the breakage of stamp-stems is the subject of a very interesting discussion between Mr. W. L. Austin and Dr. R. W. Raymond in the transactions of the American Institute of Mining Engineers. Dr. Raymond having spoken of the "fable" of crystalization, the explanation so generally given and accepted at the machine-shops and by the mill-men, Mr. Austin argues, in favor of the old theory, that the fracture always shows a granular structure and that the fairly uniform life of the stems (a year, eighteen months, or two years at best) is accounted for by the length of time necessary to effect the crystalizing. Dr. Raymond points out that the fracture does not usually occur at the points of greatest vibration, that the appearance of the fractured surfaces may not be a proof of such crystalizing process, and suggests as a substitute explanation that the breakage may result from minute fractures between the iron particles uniting in course of time to form a larger break, when the final rupture takes place. Dr. Raymond also says that the crystalization theory may do harm by serving as an excuse for bad workmanship on the one hand and an acquiescence in the hopelessness of the case on the other. The question is by no means as simple as might appear. It reopens the whole subject of the crystalization of iron and steel as a result of long-continued jarring, the importance of which as a convenient theory seems to have lost ground of late among the authorities, among whom Mr. H. M. Howe, in his "Metallurgy of Steel," is inclined to shelve it. Unfortunately, the matter does not seem to be one which can be submitted to the test of direct experiment (unless the results in actual experience are to be taken as such), for it would be hardly practicable to devise a testing machine that would subject a specimen stem to just the jarring stress that comes upon it in actual service. The fact that the parts of broken stems after having been

reunited by welding and thus repaired have a fair life seems to make against the crystalization theory, for if that theory is true as regards the point of fracture it ought also to hold good as to the whole stem; that is, that the metal would naturally be expected to be changed from the fibrous to the granular structure throughout its entire length, which is not the case. Some light would be thrown upon the subject by the behavior of steel rails, were it not that other causes, notably stresses engendered by change in temperature, complicate it. The great majority of mill-men who use, and the machine shop managers who make, these battery stems certainly believe in the crystalization theory. But if it is correct, or rather if it is true as a partial explanation, it has probably been made too much of.

In a communication to this Magazine for May, Mr. Percy Williams takes issue with Mr. R. A. Parker's recent criticism (p. 761, February number) of the lesser mining schools, and suggests that the last-named writer has been affected by favoritism in implied commendation of the Columbia School of Mines; but falls into the exclusiveness of which he accuses Mr. Parker, when he says that "there are only three mining schools in the country to-day that take an active part in the education of reliable mining engineers and metallurgists—the schools at New York, Golden (Colorado), and Houghton (Michigan)." Surely the list might be extended to include the Missouri School of Mines, at Rolla; the South Dakota school, at Rapid City; the new Arizona school, the excellent courses in mining engineering at the Massachusetts Institute of Technology, Lehigh University, the University of California, and the Pennsylvania State College, to say nothing of the general technical schools like the Sheffield, at New Haven, the Rensselaer Polytechnic, at Troy, the Stevens Institute, at Hoboken, and several others which do not make specialties of mining and metallurgy, but furnish a groundwork for these branches. It is invidious to make comparisons. The views of this Department as to the whole question of mining education have been pretty fully ventilated in comments from time to time, and it would be wearisome to reopen the discussion in detail now. To sum up, *all* the schools do good work, more or less (generally less), according to kind and degree; and all of them are open to criticism on one side or another—some from disadvantage of position, some from lack of practical aim or misunderstanding of what is wanted, some from insufficient equipment, and some from "biting off more than they can swallow,"—to use a homely but very applicable phrase. But it is worth recalling, in this connection, that one prominent educator,—himself an engineer, not merely a pedagogue,—has written (p. 545, January number) that it is not his purpose to graduate *miners*, but *engineers* —which by no means indicates any depreciation of the practical side of the matter, but only a different way of looking at the purely educational side. No matter what the curriculum or the opportunities at the school, the young graduate will need practical experience afterward before he is fit to hold responsible executive positions, though a good school will have made him at least a fair assayer, surveyor, and draftsman, and therefore able to fill almost any subordinate position satisfactorily and at once.

At a recent meeting of the Engineering Association of the South, Dr. J. M. Safford described the phosphate-beds of Tennessee, which in the middle of the state occupy a definite geological horizon (Devonian) and cover a very wide area. In some places they are but a few inches thick; in others they run entirely into sandstone; while in some localities they seem to be a "bonanza." There are two distinct beds of phosphate separated by black oil-shale. The upper layer, seldom over ten inches thick, is a stratum of concretionary balls, kidney- and knee-shaped forms, from the size of a walnut to that of a man's head, sometimes loosely disposed and sometimes tightly packed together like cannon-balls. The lower layer is more important. In its best presentation it is a well-defined, continuous stratum, dark bluish or bluish-

black, rarely gray, with fine or coarse grain, resembling a bed of stone coal, both in appearance and in the manner in which it will have to be mined. Its thickness ranges from a few inches to over four feet of good phosphate rock. The total available area, though large, is not definitely known. Dr. Safford states that there is not the same uncertainty about this phosphate that there is about the Florida rock, as by careful examination of the outcrop close estimates of tonnage can be made. A cubic yard weighs about two tons and the estimated cost of mining is $1 per net ton. Analyses show 60 to 75 per cent. phosphate.

ANOTHER paper presented before the same society, by Mr. Tyler Calhoun, describes the method of handling coal by gravity at the Whitwell mines of the Tennessee Coal, Iron, and Railroad Co. The mines are situated on the side of Cumberland mountain, 1100 feet above the tracks of the Nashville,Chattanooga,and St. Louis railway. There are three openings in the face of the mountain. The coal is brought by means of tram cars to the head of a double-track incline at the central opening and there dumped into bins. From the bins, the trip cars, carrying five tons each and running in pairs, on both ends of the cable, are filled. The incline is nearly a mile long and is controlled by drums at the top with powerful band-brakes and automatic fan governors. The cable used is the patent interlocked steel wire, 1¼″ diameter. The coal is dumped over a screen at the bottom of the incline, with diamond-top bars arranged in a series of planes, with a fall of 6 inches between the planes. The railroad tracks are built on a grade and cars are moved past the chute by gravity. The use of powder in the mines is largely avoided by undermining in the day and allowing the settling of the roof to loosen the coal during the night. The mines are drained by siphons, so arranged as to be primed by one man without stoppage. So completely has the force of gravity been utilized that there is not a steam boiler on the works. Ventilation is effected by furnaces.

A TEXT-BOOK on mining that has come under the notice of this Department has a diagram illustrating the method of opening a vein-mine, in which, the vein dipping about 45°, the main shaft has been sunk in the footwall, thus increasing the distance to be driven at each successive level. With nothing in the surface trace of the diagram and nothing in the text to explain, this looks like a strange system of mining. Such work, when there is no reason in the slope of the surface to affect the choice of the position of a shaft, is sometimes done; (1) deliberately, where the hanging-wall country is much broken or otherwise bad sinking or standing ground, and (2), more frequently, where the manager has not sufficiently proved the ground to be sure which way the main dip goes.

AN example of well-directed practical work in economic geology is furnished by Bulletin No. 1 of the geological survey of North Carolina, which consists of a preliminary (but quite full) report by Mr. H. B. C. Nitze on the iron-ores of that state. This report is evidently intended to be of use, and gives the sort of information that will be of value to those who are interested in the iron-ores of the region. It begins with a clear explanation of the composition, characteristics, impurities, and commercial value of iron-ores in general, without which explanation the bearing of such a report would not be wholly intelligible to the readers for whom it is intended, and then proceeds to a detailed description of the areas surveyed. The report shows that North Carolina possesses very important, widely-distributed deposits of almost every class of iron-ore, including much of Bessemer grade.

SO many theories have been advanced and disputed as to the origin of petroleum and natural gas (which, it is admitted, must be considered together), that it may be well, for the benefit of those who have not followed the controversy, to quote the generalizations made by Professor Edward Orton, in his "Petroleum and Natural Gas of Kentucky." They summarize what leading experts regard as safe

conclusions. There are of course many minor points to be argued over, but the broad theory is thus given:

1. Petroleum is derived from vegetable and animal substances that were deposited in and associated with the forming rocks.

2. Petroleum is not in any sense a product of destructive distillation, but is the result of a peculiar chemical decomposition by which the organic matter passes at once into this or allied products. It is the result of the primary decomposition of organic matter.

3. The organic matter still contained in the rocks can be converted into gas and oil by destructive distillation, but, so far as we know, in no other way. It is not capable of furnishing any new supply of petroleum under normal conditions.

4. Petroleum is, in the main, contemporaneous with the rocks that contain it. It was formed at or about the time that these strata were deposited.

The supervisor of natural gas for the state of Indiana, Mr. E. T. J. Jordan, holds similar views. In his last report he argues that both petroleum and gas have their origin in the organic substances that were imprisoned in the sedimentary rocks at the time of their formation; that they are the products of the decomposition of the animal and vegetable matter deposited in the sand and mud-beds of the ancient oceans under the conditions then prevailing. As these substances were limited in their extent, and in some localities the conditions favorable to the generation and retention of oil and gas did not exist, it logically follows that these products must be limited in extent. Also, that the formation of these products in commercial quantities, if any at all, has ceased many ages ago. Now if this be true, and experience bears Mr. Jordan out in the belief, then we may be sure that the time is fast approaching when the entire quantity will be exhausted. Turn whatever way we may in our exploration and theorizing, these facts stare us in the face. Within all the rich gas- and oil-fields this end has been hastened by reckless extravagance and waste. Mr. Jordan estimates that in the Indiana field alone, during the first years of gas development, 100,000,000 cubic feet of gas were wasted every day, and that, at the low prices ruling, the waste to the present would amount to upwards of $20,000,000. Similar deplorable statements might be added regarding other gas-regions. A few years ago it was calculated that 60,000,000 feet per day were burning from waste-pipes connected with the Pittsburgh supply alone. Latterly there has been a reaction in favor of economy; but it comes rather late.

AMONG methods of concentration not usually cited in the books, and perhaps not known to some of our readers—if ever put into practice by any of them—is one which commands attention because of its simplicity and originality. An old account says: "The natives of Aruba island, one of the Leeward islands in the Caribbean sea, pour the water containing the gold upon the woolly head of one or more of their number, which is a very effectual means of arresting the gold." We have all heard of sheep's pelts (the famous "golden fleece" of mythology) and strakes of cowhide (tanned with the hair on) being used for the same purpose, and from these has been evolved the modern blanket sluice; but the portable native article is probably the father of all similar devices.

THE department of mining engineering of the Pennsylvania State College favors us with the results of a compilation of the reports of the Pennsylvania coal-mine inspectors in regard to accidents during the year 1893. For seven anthracite districts (the new eighth district not reporting), the figures are: coal produced, 44,083 428 tons; employés, 112,917; fatal accidents, 426; accidents not fatal, 1039. The average tonnage per fatality was 105,211, and per casualty, 42,882. The fatalities were 1 in every 270 employed; other accidents, 1 in every 109.

The ten bituminous districts produced 45,322,559 tons; number of employés, 73,410; fatal accidents, 129; accidents not fatal, 323; tonnage per fatality, 351,338; tonnage per casualty, 140,317; number of employés per fatality, 639; number per casualty, 244.

An analysis of these figures brings out some striking conclusions; that is, so far as

one year's record indicates. With an almost exactly equal tonnage in anthracite and bituminous coal-mining, it appears that the men employed in the former branch greatly outnumber those in the latter, and that, while a bituminous-coal miner's life is measured by 351,338 tons produced, the anthracite collier's life stands for only 105,211 tons, or less than a third as much when rated according to quantity of coal raised, though there is less discrepancy if the relative value were considered. In both kinds of mining the specified causes of fatal accidents rank in the same order: falls of roof and coal, accidents connected with mine-cars, etc., from gas- and dust-explosions, and from the use of powder. Accidents classed as miscellaneous are irregular in number.

AN inventive genius has worked out the details—on paper—of a combined smelting-furnace and steam-generator. He has evidently been struck with the loss of heat in the discharged water of the ordinary water-jacket furnace, used in lead- and copper-smelting, and proposes to utilize it in this way: The two shells of the jacket are strongly stayed together to resist the steam-pressure to be raised. A connection is made with what is called a boiler, but is really a superheater, placed at a higher level than the top of the jacket—and there you have it. Not satisfied with this achievement, it is proposed to feed the jacket with water from a tank in which the molten slag is run and granulated, thus pre-heating it. There are doubtless many possible ways of utilizing the waste heat of smelting stacks, some of which accomplish this in part. But this is not one of them. One evident objection is that the plan nullifies the object and function of the water-jacket itself, and these are far more important than the saving in fuel sought to be secured. An effective water-jacket needs to be well filled with water,—not with part water and part steam,—so that a good circulation and avoidance of over-heating and priming are essentials. Steam is no protection to the inner shell; the moment the water leaves an exposed surface the molten metal would instantly cut through, and in the upper portions the destruction, though slower, would be as certain.

It would no doubt be feasible to use the waste hot water (at or nearly at boiling temperature) in feeding the boilers, if this were done in a reasonable way. The waste heat in the escaping gases from lead-or copper-smelting furnaces could also be utilized to a certain extent, in the sume directions that have been successfully pursued in iron-smelting. There are also some related devices, such as that of setting boilers over reverberatory furnaces, where the direct heat of the furnace is thus utilized. Lately, too, a method of utilizing the heat of slag for generating steam has been introduced in Australia and patented in this country. The plan, which is reported to work profitably (giving 80 horse-power in one case), consists in inserting into Cornish or similar boilers a series of tubes, of slightly inverted conical shape, which pass vertically through the boiler. The slag-pots are emptied into the hoppers of these tubes in succession, and the molten slag communicates its heat through the tubes to the water, generating steam. As the slag cools it slightly contracts, and, owing to the conical shape of the tubes, is readily detached and dumped below. Although so favorably spoken of, the scheme has obvious drawbacks, one of which is the strain put upon the boiler and slag-pipes by intermittent action.

ONE feature of the recent great coal strikes, involving nearly 150,000 men perhaps, and spreading over twelve states, is that they occurred just at the time when so much complaint was heard about "unemployed labor" and the difficulty or impossibility of getting work, the assumed causes of the agitation culminating in the Coxey crusade. It is the old story. After the panic of 1873 there were similar strikes and "labor troubles" during the following four years, and the same complaint that no work was to be had. It is true that in many localities, and in many branches of industry, there is scarcity of work and much distress; but for this very reason, that coal strikes should occur at such a time would be an anomaly were it not for

the strong position of the strikers in view of low stocks and a threatened coal famine.

THE approaching expiration of the patents on the basic-steel process will throw the process open to the world, and it can be used by any one without paying royalty. The *American Manufacturer* states that the process in Great Britain alone has yielded more than £150,000 to the owners of the original patents, the profits, however, having been distributed among a large number of owners. This sum, though large, is not at all disproportionate, in view of the value of the method. As the *American Manufacturer* says, "the history of the basic process for the manufacture of steel, when written, will be of more than passing interest for, if faithfully recorded, it will illustrate the struggles made by those who go forward in the world of metallurgical improvement. It has seldom occurred that a metallurgical innovation has had a harder up-hill struggle against powerful adverse influences."

SOME astonishing claims are made for a new steel-hardening process, in which the article to be hardened is brought to a dark red heat, then dipped into a patented composition called "durol" for ten to twenty seconds, then heated slowly to a cherry red, and cooled directly in tepid water. Drills treated by this process are said to cut through the hardest steel without lubricants and to last much longer than ordinary drills. One naturally looks with suspicion upon any patented process involving the use of a mysterious dope, but this is said to have been in use by the large German steel-works for two years and is now being introduced into England. The nature of the "durol" composition is not stated, but curiosity would be satisfied by a simple chemical analysis.

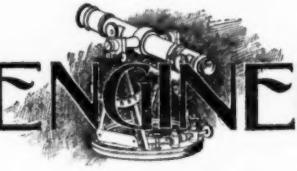
FOR a long time attempts have been made to perfect an electro-zinking process applicable to steel, especially in the form of plates used for shipbuilding, and it is now reported that the objections of slowness and expense of the operation, and defective coating caused by the retention of part of the acid solution in the zinc and setting up destructive galvanic action, have been overcome. There have been serious drawbacks connected with the old dipping process (miscalled "galvanizing"), among them the waste of zinc in iron-zinc dross and the consumption of fuel required to maintain the large baths of zinc (usually some fifteen to twenty-five tons) in molten condition. It is claimed for the new electro-zinking method that plates eighteen feet long can be coated with ease, certainty, and maximum adhesiveness, that it is much cheaper than hot "galvanizing," and that there is no distortion or warping of small pieces by heat, as in the old method.

KENTUCKY, in 1893, produced 3,246,493 net tons of bituminons coal and 45,539 tons of cannel; the former increasing considerably over the output for 1892, while the yield of cannel has fallen off, owing to the exhaustion of workable seams in certain mines..... The coal output of Missouri has increased 40 per cent. in the last five years. In 1893 it amounted to 3,190,442 tons, an increase of 173,157 tons over 1892, although the number of mines in operation in 1892 was fifty-one less than in the preceding year.

AMONG newly-proposed processes for the extraction of gold from refractory ores is one announced by a London chemist. From the published description it appears to be a combination electrolytic-amalgamation method, embodying also several old ideas. The inventor lays down the following principles as a basis: (1) the circulation of the pulverized ore between negative and positive poles; (2) a solvent liquid for the gold; (3) means of collecting the electrolyzed gold; and (4) the concentration of the positive pole. In this process, which is called the "universal," as it is intended to be applicable to all classes of refractory gold-ores (containing sulphur, arsenic, zinc, etc.), the first requirement is met by having a screw propeller set vertically near the bottom of a tank. The solvent is a dilute solution of potassium cyanide, and the collection of the gold is

effected by a bath of mercury, which constitutes the negative pole. The positive pole consists of a mass of powdered pitch or rosin consolidated by heat. The crushed ore, mixed with water, is placed in the tank, with the quicksilver bath at the bottom. The screw circulates the pulp down the center of the tank, impinging upon the surface of the quicksilver, and traveling up at the sides (on which the positive pole is laid), and back down the center, and so on, the idea being to give it every opportunity for intimate contact with the "quick." This screw device has often been tried, but generally to drive the pulp through, and not merely over, the surface of the "quick." At the same time, the electro-chemical action is intended to keep the mercury active and bright, not allowing it to become sluggish—a plan followed in the Wiswell and other methods. The chief advantages claimed for the process are that the gold is extracted directly from the ore without any other preliminary treatment than crushing; that the same chemicals are used over and over again—which cannot be wholly true, since there must be a constant loss of the cyanide solution and mercury (which involves also a loss of amalgam) in the spent pulp; that the process efficiently extracts the gold and silver from the auriferous ores, whether refractory or free; that the precious metals are obtained at once from the amalgam in the metallic state without further chemical treatment, and that any workable quantity of ore may be treated in one vessel at one operation, and the gold obtained in one day. Such a process would undoubtedly work, though probably not up to the degree of extraction claimed (over 90 per cent. in some cases); yet it is not easy to see how it should have any advantage over either of the simple cyanide leaching processes, with precipitation on zinc. But wherever there are means of cheap transportation to a silver-lead smelting establishment, the ore, if it carries a heavy percentage of base sulphurets, is best concentrated at or near the mine and shipped to a smelter, where practically all the gold (or at least nearly up to the fire-assay showing) and about 95 per cent. of the silver can be saved. It is true that a subsequent refining is necessary to get the gold and silver out of the base bullion, yet the closeness of extraction offsets this. Or, if the sulphurets are low, an amalgamation-concentration process (the one commonly employed) or a concentration-amalgamation process (the two stages being reversed) would answer, the concentrates in either case being subsequently smelted or leached. There may be room for a new method, to meet local requirements, especially where there are no cheap shipping facilities, but the metallurgist has already choice of several standard and proved methods to cover almost all conditions. It is a great mistake to suppose that refractory gold-ores are any longer to be considered a bugbear. Almost anything can be concentrated and smelted, and for heavy, base gold-ores the pyritic-smelting method is available. The new scheme evidently has the drawbacks of intermittent charges, loss of mercury and amalgam by mechanical entanglement in the pulp, cost of an expensive chemical (cyanide solution) acting merely an auxiliary part, etc. Like the other mercury-bath and lead-bath plans it has theoretical claims which are hard to substantiate in practice.

CIVIL ENGINEERING



Conducted by John C. Trautwine, Jr.

THE selection of Niagara Falls as the place for holding the annual convention of the American Society of Civil Engineers during this month is a very happy one, not only because of the great works which have been and which are being inaugurated at that place and which must form an object of absorbing interest to the visitors, but also because of the proximity of the Falls to what may be called the center of gravity of the membership of the Society. By far the larger portion of the membership of the Society is located in the Eastern and Middle States, and notably in the State of New York, so that the selection of the Falls must reduce to a minimum the traveling required of the membership as a whole, a point by no means to be neglected in these days of business depression, if a large attendance is desired.

WHEN we consider that less than half a century has elapsed since the formation of the American Society of Civil Engineers and scarcely a quarter of a century since it began to emerge from a condition bordering on oblivion, when we consider too that there are now at least four strong and fully-organized national engineering societies in the field, with a host of allied institutions, such as those of master carbuilders, locomotive engineers, etc., we can form some idea of the tendency of these recent times, toward coöperation of this sort. Coincident with the development of these national societies has been the creation and steady growth of innumerable local and sectional engineering and technical societies. So long as the national societies fail to make provision for the formation of sections in parts of the country more or less remote from the headquarters, a matter which it seems difficult to arrange satisfactorily, so long the national and local societies will have a reason for their existence.

And a measure of coöperation is obtained also among these local and sectional societies. A dozen years ago there was formed the Association of Engineering Societies, consisting, at that time, of the four societies of Boston, Chicago (Western Society of Engineers), Cleveland and St. Louis, and organized for the purpose of securing joint publication of the papers and proceedings of those societies. Since that time the Association has issued twelve annual volumes of its monthly *Journal*, and it now embraces five societies in addition to the original four. The *Journal* has grown until it has now a matter of some 750 pages annually. The Association offers a means of publication to societies so small that it would be practically out of the question for them to maintain separately a regular publication, while even the largest of the societies concerned secure, by this means, a better presentation of their papers than could be secured at anything like the same cost if they were to attempt it separately, to say nothing of the advantage of having spread before them the transactions of the other eight societies. An incidental advantage of this form of coöperation is seen in the fact that a number of the societies comprised within the Association have adopted a provision for the exchange of members with each other.

AT the May meeting of the Engineers' Club of St. Louis, one of the largest societies embraced within the Association, Past-President Robert Moore read a paper on the "Filtration of City Water Supply in the Light of Recent Researches." In the matter of filtration of public water-supplies, our European brethren have made far

greater progress than we, possibly because the natural supply there is so limited, relatively to the populatition making a demand upon it and contributing to its defilement, that filtration is more urgently and obviously necessary there than here. Mr. Moore referred to the investigations of Mr. Kirkwood on behalf of the city of St. Louis, in 1866, in the course of which he visited many foreign cities. It has long been a mooted question whether sand-filtration removes the germs of disease. It has been claimed that such filtration retains merely the solid particles held in suspension, and that it even tended to the increase of disease-germs; but it has now been shown that these fears were groundless, and that sand filtration is an effective protection against the carrying of such germs into the distribution. Mr. Moore estimated the cost of the filter system for the city of St. Louis at $2,000,000, and the annual expense of operation, maintenance, and interest charges, at $150,000. In the discussion it was stated that the water department was preparing plans and conducting experiments with different systems, and would be ready to act as soon as the funds were available.

SINCE the inauguration and successful establishment and conduct of the World's Fair, the country instinctively looks to Chicago for the inception of grand ideas. It is therefore perhaps not surprising that from the Western Society of Engineers should come a suggestion for the formation of an International Institute of Engineers. It is eminently fitting that such a proposition should have originated with a man of international reputation, like Mr. E. L. Corthell, and it is greatly to be hoped, not only for the interest of the engineering profession but for that of humanity at large, that some such proposition should be carried into effect, for it wants but a sufficient number of object-lessons of this kind to accustom the popular mind to the advantages of international coöperation, and the gradual obliteration of international boundaries.

Turning from this matter of cosmopolitan to one of local interest, but of similar import, we are glad to note that steps are being taken looking to the formation of an engineering society in Rochester, N. Y. The tidings come to us in a letter from Mr. Robert Cartwright, who evidently recognizes the difficulty of distinguishing between the civil and the mechanical engineer, since his letter-headings bear the simple imprint "Engineer," and who seems to be the prime factor in the movement, a circumstance which, to those who know something of Mr. Cartwright's energy and ability, will augur hopefully for the prosperity of the new organization.

MR. M. J. MURPHY, street commissioner of St. Louis, Mo., has issued a circular letter asking for the expression of opinions as to the feasibility of holding a national convention of the members of boards of public works, with a view to the interchange of ideas and of information respecting municipial government and municipal works. Such a convention could hardly fail to do a great and good work in the way of increasing and broadening our knowledge in such matters, and it is greatly to be hoped that it may become an accomplished fact.

AT the Hague, in July next, will meet the Sixth International Congress on Internal Navigation. Among the subjects to be considered are the construction of navigable canals designed for operation at high speed, methods of traction and propulsion upon canals and rivers, and the regulation of rivers at low water. It is desired to awaken in America increased interest in these congresses, and Mr. F. Collingwood, the Secretary of the American Society of Civil Engineers, No. 127 East Twenty-third street, New York, will transmit the applications or remittances of those desiring to attend the congress or to receive its publications. The cost of membership is only $5 annually, for the congresses receive financial aid from the governments of the countries in which they are held. A number of excursions will be made from the Hague to points of interest in Holland.

Mr. Edward P. North, whose address is at the house of the Civil Engineers, as

above, tells us that the proceedings of the congress will be printed in English, provided at least two hundred subscribers can be obtained in this country at five dollars each. Even in these times there should be no difficulty in raising this quota.

PERHAPS no engineering works give rise to more complicated problems touching the respective rights of individuals, corporations, and communities, than those connected with the flow of streams, whether those be utilized as sources of water-supply or as means for the removal of sewage. Some difficulty of this sort has naturally been encountered in connection with the great drainage channel by which Chicago proposes to reverse the current of her dirty river and let the waters of Lake Michigan flow backward through it across the divide, and, eventually, into the waters of the Mississippi. Not unnaturally, the communities along the route of this proposed stream are exercising themselves over the possible consequences of such a visitation.

Advices just received from Signor Pasquale Sasso, a noted Neapolitan engineer, give an account of a proposed work in that neighborhood, in which it is proposed to carry the waters of certain streams through the Apennines in order to supply the countries lying upon the other side. The town of Benevento, with some 21,000 inhabitants, lying thirty-five miles northeast of Naples, is situated on a hill, at the foot of which two streams—the Sabato and the Calore—flowing from the southwest slope of the Apennines, unite their waters on their way to the Mediterranean. The old town was called *Male*ventum until it became a Roman colony in 268 B. C. It stood on the Appian way and boasted of a triumphal arch to the emperor Trajan, and the arch is still standing. It was furnished with water by means of an aqueduct about fifteen miles long, and carrying over 86,000 cubic meters daily. At the foot of the opposite, or northeast slope of the Apennines, stretches the sparsely populated plateau of the Puglia, devoted chiefly to grazing; and, in order to supply this territory with water, various schemes have been on foot for thirty years or more, for tapping the sources of some of the streams of the southwestern slope, among others those of the Calore. But Signor Sasso, in his pamphlet, calls attention to the injury which would thereby be wrought upon the inhabitants of Benevento and of the surrounding district, and of the advantages they could gain by diverting these waters to their own use. The head waters of these streams are found at an elevation of about 1500 feet above the sea, and they furnish, at their minimum flow, over 500,000 cubic meters daily. The qualities of the water are practically the same as those which formerly flowed through the ancient aqueduct of which we have spoken, and which now are diverted for the uses of Naples. Signor Sasso sketches briefly an ambitious scheme by which a considerable portion of this water could be utilized, at a cost of some $5,000,000, to supply a large tract of country, including the town of Benevento, and supporting a population of about 167,000 inhabitants; but, in view of the difficulty of securing so large a sum, he devotes himself chiefly to elaborating a more modest project, costing some three hundred thousand dollars, and supplying simply the town of Benevento and the country lying along the route of the aqueduct. The latter would be about twenty miles long, with a cross-section of 0.5×0.5 m., covered with a semi-cylindrical roof, and would have a slope of 1 in 1000. Such an aqueduct, by Darcy and Bazin's formula, would have a velocity of nearly 1 meter per second and would carry the 230 liters required for the purpose.

WHEN we remember the violent opposition to the introduction of the trolley system, which scarcely a couple of years ago manifested itself in Philadelphia as in other cities, and which found vent in overflowing mass-meetings and in vehement protests from the local press; and when we contrast this with the present condition of affairs as respects the construction of trolley lines, and with the evident favor which the new system finds in the eyes of the populace, we are irresistibly reminded of the transition in the feeling of the mob

in "Julius Cæsar" under the speeches of Brutus and Mark Antony. In this case, however, Antony, as personified by the traction company, after allowing Brutus to exhaust his efforts upon the audience, instead of retaliating in like kind, quietly secured permission to construct its first line in an out-of-the-way district, and trusted to this object-lesson to make speeches for it. The result has proved the wisdom of this course, for now when trolley speaks no dog barks.

Not the least of the benefits conferred by the introduction of the trolley system is the incidental one of the long and sadly needed improvement of the street-paving of the city. The passenger-railway companies, in consideration of the privilege of constructing and using their trolley systems, are required to pave the streets from curb to curb with improved paving. In many cases this is of asphalt and in others of granite blocks, and it begins to look as if Philadelphia, so long conspicuously deficient in this respect, would shortly become one of the well-paved cities of the world, were it not for the fact that, according to the local press, the specifications are so worded as to give a monopoly of the work to a single firm, with the result that fears are entertained that a further expense will be entailed by the necessity for the erection of awnings to preserve the new pavements from the ruinous effects of the showers of spring and the suns of summer.

Broad street, which may be regarded as the backbone of the city, and which extends in a straight line from League island at the south, for a length of over seven miles to the northern city limit, a line unbroken except by the great City Hall at the intersection of Market street, is now asphalted over the greater portion of its length.

UNTIL recent years the street-car and the city passenger railway have occupied a very modest position in the world of engineering, and have enlisted scarcely a fraction of the attention which has been devoted to the pressing and large-scale problems of transportation between distant centers of population. One of the most remarkable signs of the times, however, is the revolution which has taken place in this respect, a revolution which owes its existence largely to that great discovery of Siemens which permitted the application of electricity to the transmission of power upon a large and practical scale. To-day the subject of intramural transportation is rivaling that of steam railroading in importance and in the attention bestowed upon it, and even bids fair at no very distant date to become the more important branch of the two. Scarcely a decade has passed since the time when the occasional reports of electrical railways in operation in more or less obscure towns in various and generally remote parts of the world were received with something approaching incredulity, and were of course met with the usual prediction that such innovations would never work in practice. To-day finds almost every little town the center of a great and rapidly growing system of radial lines connecting it with its more or less distant neighbors, and it seems almost certain that the next ten years will find at least the more densely populated sections of our country covered with a complete net-work of these lines.

AMONG the interesting early drawings left by the elder Trautwine is one which he prepared when about eighteen years of age, by direction of his employer, the late William Strickland, for the edification of Jesse Hartley, Esq., of Liverpool, who was at that time visiting this country in search of information for his guidance in the improvement of the port of Liverpool. The drawing, which formed a part of the exhibit of the Pennsylvania railroad at the World's Fair in Chicago, represents one of the old ferry-boats moved by horses, which then plied across the Delaware river between the cities of Philadelphia and Camden. The horses walked continuously on a horizontal tread-mill placed amidship of the boat, and the power thus generated was transmitted by means of beveled gearing to the paddle-wheels. Trautwine and one of his companions in Mr. Strickland's office were detailed to inspect and measure

the boat and to prepare the drawing from the measurements thus obtained.

Early in 1851 the same engineer designed a suspension bridge, with four spans of 1000 feet each and two of 500 feet each, to cross the Delaware river at the same point, and since then numerous designs have been offered for this purpose, but the passage of the river is still effected by steam ferry-boats, the successors of the antiquated *team*-boat depicted in the drawing referred to. The lowest bridge on the stream is that of the Pennsylvania railroad at Trenton, 30 miles further up, at which point is the head of tide-water. Now, however, it begins to appear that the river at this point may some day be spanned by a bridge. A bill has been introduced in congress authorizing a company to construct the bridge, provided the assent of the states of New Jersey and Pennsylvania shall be first obtained, the plans of course to be subject to the approval of the secretary of war. When completed, the bridge will be a post-road, over which the United States mails shall at all times pass free.

THE new bridge, however, is not to be the long desired highway bridge joining the cities of Philadelphia and Camden, and crossing the Delaware at Market street, but primarily a railroad bridge, designed, evidently, to connect the Pennsylvania railroad system on the right or Pennsylvania side of the Delaware with its very important system in the southern portion of New Jersey, which connects Philadelphia with the innumerable seaside resorts lining the shore of that state. Only incidentally and permissibly is provision made in the bill for the adaptation of the bridge to highway purposes; and the fact that its location is to be several miles above the crossing referred to renders even this provision of no great account; for very little, if any, traffic would go so far up-stream in order to avoid the short trip across the river by ferry. The bridge is to have a channel span of 500 feet, with a clear head-way of 40 feet and a draw span of 125 feet clear each side of the pier.

Philadelphia has long felt the need of a better highway to the sea than that provided by the long and tortuous channel of the Delaware river, and now, notwithstanding the government has done much to improve that channel, the citizens seem to be thoroughly aroused to the importance of the construction of a ship canal to provide the necessary outlet. A public meeting was recently called by the mayor at the request of leading firms and citizens, and that official appointed a canal commission, composed of eleven prominent men. Members of this commission, accompanied by representative citizens of towns lying upon the proposed route of the canal, have since gone over the route, which will ascend the Delaware river to Bordentown, a short distance below Trenton, N. J. From this point the route will follow, more or less closely, the bed of the existing Delaware and Raritan canal, which will be widened for the purpose, but the rectifications proposed in the course of this canal will shorten its length from forty-four to about thirty-four miles. There will be a tidal lock at each end of the proposed ship-canal, and two locks at each end of the summit level, which will be about twenty-two miles long and fifty feet above the sea-level. It will be seen that this project resembles that of the Manchester ship-canal in this, that in each case the canal is a means by which an inland town reaches out to the harbor of a prosperous rival which has hitherto enjoyed the lion's share, if not the whole, of the shipping which it is now sought to divide. Professor Lewis M. Haupt, who from the first has taken a warm interest in the project, recently pointed out, in the *Journal of the Franklin Institute*, in an article entitled "The Manchester Ship-Canal and its Lesson," the parallelism between the two cases.

THE Iglawa viaduct, near Kanitz-Eibenschitz, in Moravia, on the railway line joining Vienna and Brunn, was built in 1868–70 by F. Cail & Co. and the works at Fives–Lille. It has six spans of about 200 feet each, and the rails are about 140 feet above the waters of the Iglawa. It

is a single-track viaduct, with continuous trusses about 18 feet deep, having parallel upper and lower chords. These were supported on five cast-iron piers, each of which consisted of four tubes filled with concrete. The entire cost of the structure was about $350,000. Owing to the unequal contraction of the iron and the concrete, serious defects began to exhibit themselves soon after the erection of the bridge. Longitudinal cracks appeared in the cast-iron tubes, and it is said that it literally rained rivets and bolts upon the site of the bridge. This naturally gave rise to lively apprehension on the part of the traveling public, and to corresponding anxiety on the part of the railway officials. It was proposed at one time to replace the viaduct with one of stone, but this idea was abandoned, and it was determined instead to replace the old cast-iron piers with new ones of wrought-iron, and this work has been carried out without interruption to the passage of the thirty-six daily trains.

The old pier-legs were utilized for the erection of their successors without the necessity of constructing special false works, and, after the erection of the new piers, these in turn served for the removal of the old. The quadrangle formed by the four new legs of each pier is placed just within that of the four old ones. After the piers were in place, the maximum interval of three hours between trains was utilized for the jacking up of the trusses and for lowering them upon their new supports. This was accomplished by means of hydraulic presses. One of these presses burst just as it had lifted its burden to the maximum height, but the precaution had been taken of inserting piles of iron plates under the lower chords of the trusses as they rose, and thus, although the truss had been raised some 40 inches, it fell but one or two millimeters.

As first constructed, both ends of the continuous truss were left movable, with the design, however, of fixing the end nearest Brunn. It therefore became necessary, after all was in place, to move the entire superstructure close up to the face of the abutment at the Brunn end, previous to fixing it there, so as to allow the space of 60 millimeters (about two inches) required at the Vienna end to allow for expansion. The moving of the superstructure was effected by means of its own expansion and contraction under changes of temperature, wedges being placed alternately at the two ends in such a way that the expansion of the truss during the day and its contraction during the night should cause it to creep, caterpillar-like, into the desired position. Owing to the fact that this operation was performed at a season when the diurnal changes of temperature were of but slight range, the operation required several days.

IN describing the new Tower bridge at London, in THE ENGINEERING MAGAZINE for April, we took occasion to refer briefly to a number of remarkable devices which had been submitted for crossing the Thames at that point without forming a permanent obstruction to the navigation of the river. Among these was the design of Sir G. Barclay Bruce for a rolling platform which was to move across the river upon the tops of piers so placed that the platform should at all times rest upon at least two of them. Somewhat similar to this in fundamental principle, and yet widely different from it in its application, is the bridge of 160 meters span, designed by the engineers de Palacio and Arnodin, and recently erected over the River Nervion, in Spain, between Portugalete and Las Arenas. In this case a tall pier is erected on each side of the stream, and the two are connected near their tops by a horizontal platform. Thus far the structure is in fact a suspension bridge, with main cables and back-stays, but the elevated floor joining the two piers has no direct connection with the ground. From it, however, is suspended a traveling platform, elevated only so far above the water as to be beyond the reach of the highest waves. This traveling platform is capable of conveying railway-carriages and other vehicles, and can transport 150 persons across the stream in one minute. The fixed elevated platform, from which the traveling platform is suspended, is placed at such a height that tall vessels can readily pass underneath it.

OWING, no doubt, to the dangers, real or imaginary, attributed to the trolley and its wire, the new system seems to have found its most striking development in and about the smaller towns, where population is comparatively sparse, and has been looked upon askance by the larger cities, where danger to life through shock and to property through fire, is more seriously imminent.

Boston, it is true, has for some time rejoiced in, or suffered from, an extensive system of trolley lines, but their development has scarcely begun in New York or Chicago, although we note that ordinances permitting their construction have been enacted in the latter city. Philadelphia, despite its proverbial conservatism, seems to be following next in the lead of Boston, so far as the large cities are concerned. Several years ago a storage-battery line on Lehigh avenue in the northern portion of the city was put in operation, but the batteries were soon abandoned, and horse-power reverted to. For more than a year, however, the Philadelphia Traction Co. has had in operation a line crossing the city from east to west on Bainbridge and Catherine streets, in the southern section, and within a year it has added parallel lines on Morris and Tasker streets, still further south, while the last few months have witnessed the construction and eminently successful inauguration of the company's north and south lines on Thirteenth and Fifteenth, Twelfth and Sixteenth streets. Indeed, a stranger visiting the city during the latter half of 1893 might have imagined that the entire street system of the city was undergoing an upheaval, for it seemed as though the majority of the streets were rendered impassable by the preparations for the trolley lines; and now the chief of the electrical bureau is credited with the statement that every street-railway line in the city has applied for and obtained the privilege of constructing a trolley system. Among the lines where the work of reconstruction is now in progress, are the Hestonville, Mantua, and Fairmount, running chiefly upon Arch, Race, and Vine streets, of which Mr. A. Langstaff Johnston is in charge, and the Frankfort and Southwark, or Fifth and Sixth streets line, which began life, as the first street-car line in the city, during the early childhood of the writer.

It seems much to be regretted that it has not been found advisable in Philadelphia to use the grooved rail, which renders travel for vehicles crossing the tracks so much safer and more comfortable. The chief objection to that form of rail seems to be its liability to pack with ice in cold weather.

WITH the phenomenal growth of intramural and suburban systems of transportation, the question of their control and ownership becomes a burning one. If it is important that cities should control their supplies of water and of gas and their sewerage systems, in order that a harmonious system may be obtained in place of a series of warring interests, it would seem no less desirable that the town should control the means of transportation by which its citizens reach its various portions and the outlying districts. The New York board of trade, we notice, has approved the plan of Mr. Abram S. Hewitt by which the title of the proposed rapid-transit system for that city is to be placed in the city itself. The operation of the system, however, is to remain in the hands of a corporation, the choice of the corporation to be determined by the annual rental which it will bid to pay. The construction of the system, according to Mr. Hewitt's plan, will be superintended by a board of engineers appointed by the city, who will also see that proper accommodations are provided for the public.

This rapid extension of the trolley system, so greatly facilitating intercourse with the suburban districts, must in a short time revolutionize many of our habits of city and country life, greatly relieving the pressure of population in the cities themselves and enabling their inhabitants to find homes under far better hygienic conditions.

MECHANICAL ENGINEERING

Conducted by Henry Harrison Suplee.

IN a paragraph in this Department in a preceding issue attention was called to the fact that much information may often be gained regarding engineering problems by assuming the members of a structure to be replaced by the observer himself, and thus reasoning out the problem, so to speak, by an *argumentum ad hominum* not perhaps exactly of the kind intended by the earlier logicians. This idea is by no means limited to the investigation of statical problems, but may be applied to many other subjects with results which are at least interesting and may possibly become valuable. The writer well remembers how, a number of years ago, he climbed upon a pedestal in order to escape the pressure of a surging crowd, and how, from this vantage point of observation, he could see the action of a fluid, the molecules of which were composed of human beings alleged to possess at least a certain amount of free-will in the control of their actions. A disturbance at one point caused those in the immediate neighborhood to jostle each other and the resulting motion could clearly be seen to pass over the whole multitude in constantly widening circles of waves, identical in appearance with those produced when a pebble is cast into a pool. Each individual acted as if he thought he were pushing and crowding on his own independent, individual account, while, in reality, the whole mass was moving in absolute accordance with the mathematical laws of fluid motion. In like manner the "throttling" of a crowd passing through a narrow entrance-gate is not unlike the impeded flow of steam through inadequate ports and passages.

The fact that a cannon-ball fired horizontally will reach the ground simultaneously with one dropped at the same instant from the same height may not be self-evident to every one, but if the idea be illustrated by a ball dropped from one's hand while riding in an express train at full speed, it will at once be seen that the time of falling must be identical with that case in which there is no horizontal motion.

The real value of such methods lies in their availability to simplify conceptions of problems which may be presented in unnecessarily complex forms, and thus enable the actual and controlling conditions to be grasped immediately, leaving more accurate determinations to be made thereafter.

THE speeds which have been made by the various cruisers of the United States navy, usually based on a four-hours' run under the most favorable conditions, may be compared in an instructive manner with the average speed of the Cunard liners, *Campania* and *Lucania*, during the year's steaming, just concluded. The *Campania*, being the first completed of the two steamers, has rendered the greater amount of service, having traversed about 50,000 nautical miles, at a mean speed of 20.304 knots per hour, while the *Lucania* has made practically the same speed, it being 20.394 knots average speed, for over 33,500 nautical miles. When it is considered that these speeds have been maintained under continuous commercial conditions of actual service intended to inure to the benefit of the steamship company, rather than to gain a premium for the builder one is tempted to ask how many of our new cruisers could maintain anything like such a continuous rate of speed as 20 knots for six consecutive days without a hot bearing, leaky boiler, or mishap to any important auxiliary! It must also be remembered that this record includes all the retarding influences of adverse weather throughout the year, in a season which has had rather more than the average share of heavy weather such as would be considered entirely unfit for any possible trial run under any circumstances.

MUCH has been written upon the subject of mechanical drawing, and there are many admirable text-books upon this important branch of technical education. Nearly, if not quite, all the treatises, however, consider the drawing entirely with regard to its first and principal purpose,—that of serving as a means of conveying the ideas of the designer to the constructor who is to execute the work,—and do not give enough attention to the secondary, but still important, service of a drawing as a record for future consultation. Nearly every draftsman and engineer knows how often he has to get out his old drawings for reference and comparison, and, when he has thus to work them over, he finds many things which might have been done in a more convenient manner for use, had he only considered them in the first place. When a man is endeavoring to produce a new design he should be able to concentrate his mind upon the immediate subject as much as possible, and the fewer distracting conditions he has about him the better he can work, and among the petty annoyances which disturb the train of thought a few may be worth enumerating.

In the first place, there is no earthly reason for the continuance of the time-honored practice of writing the dimension figures along the direction of the dimension lines to which they belong, thus necessitating the twisting of one's neck or the shifting of a large sheet every time a vertical dimension is to be consulted. The rule of writing all dimension figures on the horizontal line is not only easier in the first place, but immensely more convenient for every one who has to use the sheet thereafter. This method of figuring also improves the general appearance of the drawing to an extent which can only be appreciated by comparison with sheets figured after the old method, and, if introduced by a few leading establishments could scarcely fail to become as general in the United States as it has on the European continent.

The disposition of figures is also a matter which should be considered from the standpoint of the user rather than that of the draftsman, as he may discover when, in turn, he becomes the user himself. The best of all rules in this respect is the altruistic one of "put yourself in his place," which, indeed, applies to many other things, mechanical and non-mechanical as well. The general abolition of the so-called "shade-lines" is a gain, so far as practical use is concerned, which none can deny, and yet, not so many years ago, this was a matter which many draftsmen regarded as rank heresy. After all, the idea of "common sense applied to the use of materials" covers this subject as well as many others, even when the materials consist only of paper, pencil, and—brains.

THE subject of coil boilers, which was briefly discussed in this Department last month, was the basis of a paper presented at one of the informal meetings of the Mechanical Engineers, by Passed Assistant Engineer W. W. McFarland, U. S. N., and the discussion which followed was chiefly interesting in that it showed that a certain undefinable timidity was really all that kept many from endorsing the use of coil boilers in many places where their use is yet withheld.

Mr. McFarland's paper was mainly confined to data from experience with coil boilers in the United States navy, and especially with the performance of the Thornycroft boilers on the *Cushing* and the Ward boilers on the *Monterey*. To use Mr. McFarland's exact words, upon an important point, "the experiments on the Ward and Cowles boilers in competition, and those on the Thornycroft boilers of the *Cushing* and the Ward boilers on the *Monterey*, show conclusively that coil boilers will stand any amount of forcing without injury, as these were all subjected to air-pressures of two inches and over for long periods without a single leak being developed. We fancy that there are few shell boilers of which this could truthfully be said, and it must be remembered that the boilers of the *Cushing* have been in use at least five years, so that, in that instance at least, the experience is beyond the experimental stage. If multiple expansion is to be car-

ried advantageously beyond three subdivisions—in other words, if we are to reap the possible advantages which may reasonably be expected to be obtained from quadruple- and quintuple-expansion engines—we must certainly look to some form of coil boiler to obtain with safety the steam-pressures which such expansions demand. The experience of the members of the American Society of Mechanical Engineers seems to be limited to boilers for launches and similar small craft, and hence no one had any contributions of practical experience of the magnitude which was given in the paper. It seems as if thorough tests on land under continuous and trying service should be the next thing in order, and the promise which is held out certainly makes such tests worthy of serious consideration.

IT has been quite common of late to present economical or scientific subjects under the guise of accounts of events taking place at some future date, and the attractiveness of such methods, to both writers and readers, has caused many such tales to be published. The most recent of these is a leading article in one of the prominent literary monthlies, professing to narrate a naval engagement between two modern battle-ships, in a war dated only a few years ahead, and so presumably before present appliances have become obsolete. Notwithstanding the fact that the modern battle-ship is essentially what Captain Ericsson called a "fighting-machine," it might be supposed from the article in question that battles in the near future would be fought much in the same way as that between the *Kearsarge* and *Alabama*, for instance, and that heavier armament and greater destructiveness were about the only advances (?) which had been made in recent years.

It is most instructive to turn to a series of articles which appeared a few years ago in *Engineering*, entitled, "The Story of the Battle of Port Said." This decidedly sharp criticism of the state of affairs in the British navy at that time was far more instructive and valuable, and more entertaining, than any melodramatic effusion describing a theatrical naval engagement could possibly have been, and the manner in which it revealed defects in equipment and operation, as well as the occurrence of "the unexpected, which always happens," make it worth re-reading and applying to matters nearer home. Vessels which had made phenomenal speeds on trial-runs showed distress in remarkably short runs at moderate speeds, and the confusion which existed on some of the battle-ships, after certain men who alone knew and understood the manipulation of the special hydraulic apparatus and other devices had been killed, sets one wondering what would become of some of our numerous electrical devices in an engagements should the specialists become disabled early in the fight! These and other interesting points, for details of which we must refer those who may be interested to the original articles, were supposed to be made the subjects of a special court of inquiry after the battle, and the investigations were quite "official." In the story of our contemporary, however, none of these things happen, and we must congratulate the writer upon the wonderful completeness with which everything mechanical on his vessel must have performed, and return thanks that our ships are not as those of other nations in this respect.

IT is interesting to note that the manner in which the broken shaft of the *Umbria* was repaired at sea has given rise to consideration of portable flange couplings to be carried among the "spare" stores for such emergencies. A three-part flange-coupling which can be placed between the thrust-collars of a propeller-shaft and bolted to a similar coupling-flange between the next pair of collars is the subject of a recent British patent, and if all the various places in which a shaft might break could have similar consideration and anticipation such repairs at sea might be more easily and safely effected. It is probable, however, that the shaft would always break at the point for which no especial coupling was carried, owing to the well-known "total depravity of inanimate things."

THE increasing popularity of graphical methods of calculation, as compared with the more precise (but not necessarily more accurate) analytical methods, suggests some thoughts which may not be out of place in this Department, bearing, as they do, upon problems directly relating to the daily work of the mechanical engineer.

The great attraction of graphical methods lies in the directness with which the result is attained and the fact that the whole work is before the observer in a shape to be grasped as a unit, instead of a succession of statements. Every one who has used tables and curve-diagrams to express the same set of relations,—such, for instance, as a set of Regnault's steam tables compared with a curve of steam-pressures and volumes,—will appreciate this fact. Even the simple exercise of graphical addition, marking off the successive items on a strip of paper and then measuring the total length, is in fact doing what is considered quite a feat by the expert arithmetician, as it permits items of several columns in width, as well as fractional quantities of all denominations to be added simultaneously, without previous reduction.

The clumsy notation of the ancient Greeks and Romans compelled them to direct their mathematical ingenuity almost entirely to the solution of geometrical problems, and any one who has seen even a simple example in elementary arithmetic worked out in the Roman system of numerals can imagine how the veriest schoolboy of to-day would appear as a mathematical prodigy merely because of the fact that he possessed the infinitely superior notation possible with the Indian (miscalled Arabic) numerals. When we consider, however, how many unnecessary details of reduction and similar manipulation are avoided by the most elementary graphical processes, the reflection that we are entirely too well satisfied with our present system forces itself upon us. May it not be possible that as great an improvement upon the Indian system as that was over the Roman is possible, and that, while the solution by graphical methods is only an indication of what may be attainable, yet the indication may be clear and the solution not far off?

There are some analogies in our present system which point in the same direction,—notably the curious properties of the figures nine and seven; and the manner in which such arithmetical prodigies as Mondeux, Colburn, Bidder, and Inaudi operated makes one regret that the processes by which they performed calculations mentally which required much longer time for "experts" to accomplish with pencil and paper, were not investigated, at least to an extent which would give a clue to the conscious or unconscious process employed. The direct methods of nature go immediately to the results which they must produce, just as a freely suspended chain forms a catenary without requiring any guidance, and it may not be too much to hope that some day we shall be able to think and calculate by methods as direct as the action of the forces which we are endeavoring to grasp.

THE question of the relative economy of a main central engine against several separate motors is one which cannot be decided broadly, as the conditions of transmission and similar subjects vary in different locations to such an extent that each case must be decided on its own merits. It seems, however, in many instances that the loss of power in transmission forms far too great a proportion of the total to warrant the concentration of power in a single engine in large establishments, especially when the various buildings to which the power is transmitted have been added from time to time, and placed with regard to other conditions than those of economical transmission of power.

When it is considered that in very many instances more than half the power of a large plant is absorbed simply in getting the other half to the place where it is to be used, it certainly appears as if there was room for improvement, and, although some concentrated establishments keep the "friction" load down as low as 40 per cent., yet there are more in which it exceeds 50, and some where it is greater than two-thirds of the total power de-

veloped by the engine. We have heard the missionary society sneered at because it required two dollars of expenditure in administration for every dollar which it transmitted to the heathen, but it is to be hoped that the sneering was not done by a mechanical engineer, or at least that the vitreous nature of his residence was not perceived by the party under criticism. Just how this loss in transmission is divided can hardly be determined, but from the proportionally low specific transmitting capacity of shafting as compared with belting or with rope transmission it seems as if the greater portion of the loss was due to the long lines of shafting with which every manufacturing establishment is filled. A central steam-generating plant with a moderate number of engines, placed with especial care to avoid complications in transmission, together with a judicious use of high-speed rope transmission, would seem to offer the most feasible means of keeping down the transmission losses to a minimum, and when this is supplemented by electrical transmission to the tools, so as to obtain the great advantage of a transmitting medium, the resistance of which ceases when the tool is not in use, we shall no longer hear of engines with a friction load of more than half the entire power which they develop.

IN a recent issue of this Magazine reference was made to the mechanical engineering problems which had been more or less imperfectly met in the important subject of safe- and vault-construction. There is a new element which may enter into this subject and make the task of protection against burglars more difficult than ever. The present methods of protection assume that, if a vault is strong enough to require more than a few hours' work with hand-drills to penetrate it, it is safe against attack during the time it is left alone for a single night. It may not be impracticable, however, for the burglar to come provided with a light electric drill and a cell or two of storage battery in his kit, and with such weapons at his command he might soon pierce a small hole, inject the liquid explosive and be off before he could otherwise have made any impression upon the vault. While this has not as yet been attempted, it is not always wise to allow one's self to be taught by the somewhat expensive tuition of a burglary, and it should be within the province of the engineer to guard against such a possible method of attack.

THE old idea of reversing the motion of an engine by shifting a single eccentric directly across the shaft has been revived in a new form by Mr. David Joy, the well-known inventor of the Joy valve-gear. Mr. Joy's design does not differ in principle from the old wedge-motion of Dodd, except that the eccentric is shifted by means of hydraulic cylinders and plungers operated by a solid rod of oil communicating through the center of the shaft and controlled directly in the case of a locomotive engine, from the cab of the engine-driver. That there may be difficulties to be overcome in the matter of leakage is doubtless true, but at the same time the directness of the construction appeals very strongly to the engineer who has a due regard for the importance of simplification in all possible details. The action of a liquid rod and the solidity of such connections is sometimes brought most forcibly to one's attention when a bad case of water-hammer occurs in a large steam-pipe connection, and the persistence with which the apparently solid liquid refuses to escape through the most invitingly prepared openings makes it interesting to observe the success which may attend this effort to utilize this most annoying enemy. A few ounces of water in a cylinder will knock the head out as promptly as if a monkey-wrench had been carelessly left inside, and, in fact, there is less evidence of compression to be observed in most liquids than in many of the solid materials of construction. Water rods have been used successfully in mine-pump connections, and every hydraulic press is practically a hydraulic lever, and surely the difficulties to be overcome in the matter of leakage are not so insuperable as to make a determined effort unadvisable.

THE YOUNG MECHANIC

Conducted by Frank Richards.

THE genial spring and the early summer freshness draw us out of doors and we see the work of the garden and the farm going on. Nothing draws our attention more than the pruning of the vines, which is always to us more or less a heart-breaking process. That things should grow so lustily, and then be cut off from their share in the fruition, cannot but savor of waste and disappointment. But now a new and a still more outrageous style of pruning is proposed. To promote the healthy and vigorous growth of the young mechanic they are going to cut off his roots! Witness the following fresh clipping:

A council of pedagogues has decided that the cube root must be eliminated from rudimentary instruction in arithmetic. In the early days the schoolmaster explained the problem very lucidly by the use of wooden blocks and birch switches. But there has been a great decrease in the timber supply, and hence the study may have increased in cost. Anyway, it is of very little use in ordinary business, and the modern student can find something more engaging in the study of "puts and calls."—*Troy Times.*

This proposition should not be a surprise to anybody. It is no more than should be expected as things go, and the flippant tone in which the suggestion is conveyed is of a piece with the rest of it. If any one will look into one of the "practical" arithmetics of the day he will get an impression that it is gotten up for a class of young brokers and bankers and general financiers, and he will find it hard to believe that it is really for the preliminary training, or, rather, for the entire school instruction of those who are to fill our workshops and factories and to carry on all the practical operations wherein the masses of our population are actually employed. The generally excellent arithmetic in use in the schools of New York city has about one-quarter of its entire bulk devoted to rules and examples under the general head of "percentage" alone. It is no wonder that the two or three pages taken up by "cube root" are to be crowded out. If the importance of the subject is to be estimated by the space occupied it is of course insignificant.

But the proposition means more than at first it seems to. Evolution and involution are correlated and interdependent, and to strike out one is to strike out the other. The cube root is the key to all computations relating to the weights and dimensions and general mensuration of all solid bodies. Yet this "is of very little use in ordinary business."! It is of no importance that those who are to handle our wood and stone and iron and earth in buildings and machinery and general engineering works should have any knowledge of what they are about! If the cube root is of little value, why not cut off the square root too? It can't be said that it is of any more importance than the cube root, and if one is worthless the other is equally so. Surely destructive pruning betrays the incompetent horticulturist. It would seem to be the business of the teacher not only to teach but also to know what to teach that will be of most service to the scholar, and when he makes such a suggestion as we refer to what are we to think of him? Would it not be well to prune his roots a little?

IT was always a mistake, and with our progress in all things it is becoming every day a greater one, that little education is needed for the working mechanic. Everybody knows more and has to know more than people used to, and why shouldn't he? Yet it is still common enough for a man to bring his boy to the shop with the tale that he will not learn anything at school and that therefore he ought to "go to work." In such a case the man as well as the boy needs to know more. If the

boy succeeds in getting into the shop—and the writer hereof would not take him unless there were other circumstances to change the aspect of the case—a double injustice is perpetrated. The boy is handicapped by his lack of brain tools, and the proprietor is saddled with a more or less incompetent worker. A shop-foreman of these days would tell you that one of his chief troubles with the apprentices in the shop is in their ignorance of the elementary laws of physics. The principle of the lever, the elements of geometry, the values of direct and indirect forces, the relative strength of materials, have to be learned at the expense of the business. Where, years ago, "natural philosophy" was one of the elementary studies, "physics" now belongs to the advanced classes, and the boy that goes into the shop to-day is apt to go there without as much of such knowledge as he would have carried with him a generation ago.

The "practical" in education should have reference, not to the ideal, but to the actual prospective needs of those who are to be educated. The ideal of course is that we are all to be bankers and merchants and proprietors, while the actual fact is that many of us will be running lathes and all kinds of machinery, and doing active and responsible work in all the trades, and it will be no mistake to keep this in view in the common school.

BUT while we believe in as full a schooling as possible for the young mechanic before he gets into the shop, we readily admit there are other schools besides the common schools. Any agency that will promote the habit of finding out things, and the way of doing things, and the habit of actually doing things is better than the most thorough storing of the mind with facts. Common sense is not always supplied by the common schools, but there is no getting on successfully without it. In things mechanical it is especially valuable. It leads to the doing of things by the most direct methods, and to the taking advantage of circumstances everywhere.

IT will be noticed that we have at the head of this Department a little picture of a messenger boy that we have put to run a lathe. Now it happens, curiously enough, that we are entirely ignorant of his public-school record, but he certainly did not get into our shop upon the assumption that, because he was a failure at one thing, he must be a success at something else. He was not a failure as a messenger boy, but, on the contrary, he was a phenomenal success at it. His route was in Brooklyn, and by his perambulations of its streets he became especially expert in everything relating to oblique angles, which special knowledge is likely in time to prove nearly as valuable to him in the shop as an equal knowledge of figures would be. As a messenger he had considerable training in the most direct methods of getting to wherever he wanted to go. If he didn't know the way he was more apt to ask the driver of a fire-engine than to ask a policeman, and, if neither of them could tell him, he went along and found his way without their help. In the machine-shop we are very confident that he will not be asking us how to change the stroke of a shaper, or, if he has a belt to lace, he won't want any one to tell him whether it is an open or a crossed belt. He will never be writing to a mechanical journal after the style of a certain foundry-foreman who once actually wrote the following inquiry: "As I have experienced some difficulty in lifting molding flasks, owing to the giving away of the chains, I would be very much pleased if you could give me some information as to the weight of molding sand when rammed up in a flask. The giving away of a chain when lifting a flask is a source of considerable annoyance to the molder, and an answer to my question will therefore be of interest to other readers." No doubt the "foreman" in writing this thought that he was doing a big thing. Of course he was flattering himself that he was exercising—and displaying—an inquiring mind, which is said to be a good thing to have. Well, all we can say is that, if our messenger-boy machinist, two weeks in the shop, asked us such a question, he would be likely to be snapped up very short, and he

wouldn't get any answer to his question unless our constant readiness to do a kindness let it slip before we had a chance to brace up. Don't think us severe. Here was a man, a full-grown man, a man from his position assumed to have some mental and executive ability, with the sand and the scales right beside him, writing off to Chicago, or New York, or Boston, to get somebody to tell him how much the sand weighs. The editor, who ought to know better, hunts up the weight of sand in some "pocket-book," which is probably accessible to the foreman also, and tells as nearly as he can guess what the foreman wants to know, and the foreman has had the pleasure of displaying his inquiring mind and is encouraged to ask again. "He that fights and runs away" will, contrary to the common tradition, live to run away again next time, and he who asks, instead of thinking and acting, will become more expert at asking than at thinking and doing, and will be evermore a framer of questions rather than of answers, and his notable deeds will be few.

As we took pains, at the opening of this Department, to invite correspondence upon mechanical topics, in the hope that something might come out of it of interest or benefit to some of us, we need not waste our time in saying that our correspondents when they do favor us are welcome. Here is an interesting letter:

DEAR MR. GRUMBLER:

I have been working in the shop here, learning the machinist trade. I don't get a chance to learn very fast because I have to do the same thing over and over again so much. I have been running a planer now for a week, planing a lot of pieces all just alike, and of course when I have done one or two there is nothing more to be learned at that, and so I have to wait until something better comes along to be done. I do get a chance to do different things once in a while. I can temper a lathe-tool as well as any fellow in the shop, but when it comes to annealing a piece of steel I don't seem to have much luck, and that is what I want to ask you about. Is there any secret about annealing steel that I haven't got hold of? If you can give me any points on this subject I will be much obliged.

M. T. J.

MR. M. T. J.:

Dear Sir: I am glad to receive your letter and will do what I can to give you an encouraging, if not altogether satisfactory, answer. If it will be any help to you, I will say that I think you are getting along better than you seem to think that you are. I have no doubt that you are learning every day. Many of our ideas, much of our knowledge, gets into us without our cognizance. There is very little formal teaching in life and what is undertaken in that line is not always a pronounced success. The learning that goes on is mostly through the personal act of the scholar in seizing and appropriating what comes within his reach. When we get grown up we don't generally expect to have the bread and butter and potatoes shoved into our mouths, but are content to feed ourselves. But when it comes to knowledge and skill many of us have an idea that it is to be crammed into us by teachers, and that if we have not the teacher our minds will starve. This is all a mistake. All that can be done at best is to set things before us and we must reach out and help ourselves, and if they are not set before us in inviting array we have only to reach a little farther and hunt a little keener. Discontent in a young and growing mind is only appetite, and there could be no health without it. You do not seem to be without the opportunity or the means of continually picking up knowledge as you go along, and you seem also to be profitably using your means and opportunities, and what more could you expect?

To be able to temper steel successfully is a great thing gained, in the machine-shop or in any of the lines connected with it. The operation of annealing steel is essentially a much simpler operation than that of tempering steel, and yet it is an operation attended with more failures, or with more varying degrees of success, than almost any other in the trade. Full and complete instructions for annealing steel may be put into a single sentence, and nine-tenths of those who try to follow the instructions will then fail of complete success in the operation; but, after all, the failure will be because the instructions are not implicitly followed. If I were to give instructions for annealing a piece of steel I would say (and I think my instructions would be complete): Heat the steel slowly, evenly, and thoroughly, and then let it cool slowly, and it will be annealed. This would seem to be simple enough and easy enough to follow. The steel, whether for hardening and tempering or for annealing, and especially for annealing, should be heated as hot as it may safely be done without

injury to the steel. Unfortunately, we have no sure test for the heating of a piece of steel in the fire. We have practically no better test of the heat of a piece of steel than Tubal Cain had. The only guide that we have is the eye, and it is scarcely to be expected that an inexperienced eye can unerringly determine so delicate a shade of color as the difference between just hot enough in a piece of steel and a little too hot. I have an idea that the eye of an expert tool-dresser must be as keenly sensitive to certain shades of color as the eye of an artist. The blacksmith, unfortunately, deals with absolute shades of color, while the artist's colors are mostly relative to the other tones of his picture. The absolute color to which it is proper to heat a piece of steel has to be judged by the blacksmith under different lights, varying with the hour of the day and the state of the weather, which makes it still more difficult. Different steels will stand different degrees of heat and this also has to be learned, and learned mostly by failures, and if, as Dr. Holmes says, an oculist spoils a hatful of eyes before he becomes an expert, the tool-dresser may still be hopeful of achieving a magnificent success if he has not spoiled more than a cartload of tools in the heating. If it were not for the encouragement that we get from the knowledge of the failures of others we would not have power enough in our lives to drive us along.

But after all I think that failures in annealing steel are rarely in the heating of it. The trouble is entirely in the cooling, and especially in the beginning of the cooling. Just at that point occurs a little fatal spot where we fail to follow our instructions implicitly. We make great display of our annealing-box of lime or charcoal or sand or other non-conducting material, where the steel may cool as slowly as you please, and when we get our piece of steel embedded in that and covered up snugly, we have done our full duty by it, and then if it is not as soft as cheese it is not our fault. The one little loophole where failure so often slips in is in the fact that we often allow the steel to be chilled a little before we get our slowly-cooling arrangements to operate upon it. We handle the piece with cold tongs, or with tongs much colder than the steel. The annealing-box is stuck in an out-of-the-way corner, and in our hurry we rush our piece through the cold air and that chills it, and when we get to the place where we are to bury it the annealing material may be as cold as the grave. Although it may be very effective non-conducting material, when it gets at its non-conducting work, it has first to be heated, and this heating chills the steel, and, no matter how slowly the after cooling may be effected, it is too late to do much good. If there is any "secret" about annealing steel I think that right here is the place to look for it, and if I succeed in getting you to look in this direction you will need no further directions from me. Handle your piece with hot tongs, have your annealing-box as near the fire as possible and have its contents red-hot before you put your steel in. The last of the cooling is not of much importance and it is by no means necessary to keep the steel in the box until it is cool enough to handle with your bare hands. No harm can come to it when it has got down to 500° or so.

Kindly let me know what success you have, and I will be glad to hear from you again, whether you have any success or not. Yours truly,

DYSPEPTIC GRUMBLER.

On May 5 occurred the formal opening and dedicatory exercises of the Webb Academy and Home for Shipbuilders. The exercises, conducted by Mr. Webb, were of the highest interest, the addresses being by Bishop Potter, the Rev. Dr. Collyer, and the Hon. Joseph H. Choate. No higher praise could be accorded the addresses than that they were eminently characteristic and worthy of the highest reputation of each distinguished speaker. They were of course highly eulogistic, or, let us rather say, worthily appreciative of the giver and the gift. The edifice, which is an imposing and everyway admirable one, well adapted to the uses for which it is designed, stands on Fordham Heights, overlooking the Harlem river, all of upper Greater New York, the Hudson, and the Palisades, one of the finest sites to be found in the whole breadth of our favored land. The ample grounds, the building, its equipment and liberal endowment fund are the exclusive gift of Mr. W. H. Webb, the eminent American shipbuilder. The total outlay involved is more than $2,000,000. It is given to few in this world to know such a moment of joy as must have belonged to Mr. Webb upon the complete accomplishment of so excellent a scheme of beneficence.

The purposes of the institution seem to be nearly equally divided between the provision for the declining years of aged

and indigent shipbuilders and the provision for the opening years of many young shipbuilders by their education in the line of their special calling, and it preperly finds mention here on account of the latter of its functions. The establishment is the highest expression of the profound conviction of a thorough and world approved experience as to the necessity and value of education as a help to success in an important field of activity. A man who has been remarkably successful in an honored sphere of activity, now in the years of his ripest wisdom, with his heart full of a desire to do with his means what shall be best and most helpful for his fellows, puts his conviction in this enduring form. No living man can do other than wish the institution the highest success, nor refrain from hoping that it may graduate those who will be worthy rivals of Mr. Webb in the front rank of American shipbuilders.

Mr. Webb can doubtless tell us, as other successful men have told us, of the insufficiency of his early education, of his struggles by candle-light, in the intervals between days of hard toil, to store his mind with necessary knowledge, and of the determination that grew therefrom that some others should be better equipped than he was in the line of his special calling. No doubt Mr. Webb may often have thought how much greater would have been his success if he in his day had possessed the boon of a more liberal education. In this the world will probably not agree with him, and the institution which he has so nobly endowed for educational purposes will be, in spite of him, a monument to the self-educated man, and an enduring sign of encouragement to those who have not received the highest ministrations of the schools to still manfully and hopefully do their level best.

COMMENT & CRITICISM

The Sanitary Survey of Santos.

THE sanitary survey of the Brazilian town of Santos by American engineers, noticed in the Civil Engineering department in this Magazine for May, may prove to be of more importance to the people of the United States than any other movement in Spanish America in recent times. It can not be doubted that very many interests in the United States, which otherwise might have been benefited by an extension of trade with the South American republics, have been handicapped by the dread on the part of our people of coming in contact with climatic and other conditions which they have deemed unhealthful. This is not to be wondered at when the death-rate from yellow fever in the town of Santos has been 124 per 1000 inhabitants per year. The recent war in Brazil, though furnishing columns of news for the journals of every nation, was an insignificant affair compared with the death-rate of 100 per day from yellow fever alone in the city of Rio de Janeiro. The spirit of enterprise and progress which is making itself felt in so many centers in South America cannot fail to gain an impetus from the lesson furnished by Santos, if the work outlined by Professor Fuertes and Mr. Hering should be prosecuted to completion. The result upon the death-rate there may be expected to be a repetition of the experience of Memphis and other cities in the southern United States, once dreaded by so many people as pest-holes, which now have, through acceptance of the advice of sanitary engineers, reduced their mortality rate to normal figures. The result in the case of these cities has been a steady growth in population and an important increase in industry and commerce. The adoption by Santos of quarantine, of a proper water-supply, and of a rational system of sewerage can hardly fail to be observed by the capitals of the other Brazilian states, as well as the leading cities elsewhere in South America. The important shipping-port of Pará, at the mouth of the Amazon, which furnishes the world's most important supply of india-rubber, is scarcely without a resident from the United States, although the manufacturers of this country consume by far the larger share of the rubber product of the Amazon valley. The small number of Americans engaged in trade on South American soil was emphasized by the reference to Argentine in the paper in this Magazine last month on "America's Need of Wider Markets." That the danger from the unhealthful conditions of Spanish America, bad as they are, has been exaggerated in the minds of the people of the United States, is proved by the fact that important colonies from so many European countries have been established and maintained all the way from Colombia to the river Plate. It is encouraging, therefore, to know that the value of good sanitation is becoming appreciated in the great continent to the south of us, for this fact alone will do much to encourage more thorough investigation of that continent by our engineers and representatives of our commercial classes, who can now hardly be tempted to undertake commissions there even by the offer of extraordinary rates of compensation.

H. H.

The Opportunity in Peru.

SEÑOR ANTONIO RAIMONDI, the eminent scientist of Lima, once said, when speaking of his own country: "It appears to me a thing incredible that Peru—this land of proverbial wealth—which, at the time of the Spanish conquest, filled with gold the chests of the exhausted Spanish treasury, has been, up to the present time, almost a *terra incognita* to the people of Europe." And an English nobleman lately declared, upon a public occasion, that he could not

understand how it was that his countrymen should take so much interest in Africa and so little in South America.

Contrasting the facts respecting Peru which Mr. Guillaume presents in the Magazine this month with the facts universally admitted with regard to Africa, it does seem incomprehensible that so many great powers should be engaged in a contest over the latter while almost overlooking the former, except on the idea that their hope of continued commercial greatness is in keeping as much of the world as possible under political subjection. The spirit of independence is too rife on South American soil for crown colonies to exist there. Even remote Peru has preferred to remain poor and obscure rather than wear the yoke of any old-world power. It is something for the young republic to have maintained its independence for seventy-three years, and to have made real progress and escaped total bankruptcy; the fact that it has not done more argues nothing against the country's wealth of natural advantages.

The nations of Europe have not hesitated, when Peru has appeared as a buyer, to supply her wants, but there is a further interest in the development of such a country that might prove mutually profitable. When representative citizens of a certain southern state once appeared in New York to invite the interest of a great capitalist in the mineral wealth of their section, he is reported to have doubted all of their statements, "for," said he, "if they had such resources they were fools not to develop them themselves." Later he learned that, though a whole state might be underlaid with rich iron-ore, the people might not have the skill or the financial ability to carry any part of it to market. So with Peru; without appealing for a lift, but while doing her utmost to train her sons to help themselves, the little republic does invite outsiders to occupy her lands and mine her metals and extend her railroads, on such terms as shall yield a profit all around.

To such a field the attention of enterprising Americans may well be invited—not only to Peru, which happens to be brought before our readers this month, but to others of our neighbors in the far south as well. It is not enough to profit by staying at home and selling a sugar-mill or mining plant if such should happen to be ordered. Real enterprise consists in going abroad and creating a demand—by the investment of capital, if need be—for what we are prepared to manufacture. By the way, it is worth noting that, irrespective of the sources of the capital expended in Peru, some of the most important engineering constructions there have given employment already to American talent and to American materials.

There is even less reason that Peru and her neighbors should be an unknown part of the world to the people of the United States than that they should be unknown to the people of Europe. The fact is, that the continuation of existing conditions much longer will lay our people open to the reproach—never before justly charged against us—of lacking in enterprise. Yet intelligence and judgment must be used before one plunges too deeply into a field for business so different from that which exists at our own homes. Peru is farther from New York than Nevada if disaster should befall any enthusiastic prospector.

H. H.

Wind-Mills and Electricity.

IN the March number of the Magazine, in the department of Electricity, appears a notice of an electric-lighting plant driven by wind-power, which has been for some time in successful operation in Jersey City; giving about three-horse power with a wind-wheel diameter of eighteen feet and a wind speed of about twenty miles an hour. These details are not entirely in harmony with the efficiency noted in a preceding article on wind-mills, by Professor Thurston. I should be pleased to see in your Magazine an article on this subject in detail, with drawings, if possible, giving the efficiency of wind-mills in generating power for electrical uses.

In many places on the Pacific coast, in fact, throughout the whole length of the western side of the range, the trade-wind is about as regular as the sunshine for

about more than half of the year. If the land-owners here could get exact information on the matter mentioned, it doubtless would result in the establishment of many electrical plants on the coast for lighting and other purposes. I have a "seaside home" where I find plenty of wind for several months every year, where one plant would be sufficient to provide lights for a number of houses, and it would be desirable for such places to have an estimate of actual efficiency and cost of plant.

S. S. SOUTHWORTH.

Sacramento, Cal., March 14, 1894.

Electric Haulage in Mines.

IN the department of Electricity in the May number of this Magazine appears a brief description of an electric-haulage plant in use in the Bear Run mines of the Blossburg Coal Co., Tioga county, Pa. A mine-operator reading the description mentioned might suppose that one of these 30-horse-power locomotives would haul thirty-two loaded wagons, weighing 3200 pounds each, up a 3-per-cent. grade at a speed of six miles per hour, and, upon this basis, might be tempted to order a locomotive having such a capacity for use in his own mine, where he had a similar grade. Should he do this he would find that, instead of hauling thirty-two cars, it would be doubtful if he could pull more than fifteen such cars. Space does not permit my entering into particulars of the size of locomotives required for such loads, but, in view of the wide difference between the capacity of locomotives required for certain work and that quoted in the Magazine, some comment should be made upon the figures given. Seventy-five per cent. of the electric-haulage plants in the United States have been constructed from the writer's designs, and he has found that the weight of a locomotive required for pulling a load up a grade in a mine is much greater than the power required on a surface road, on account (1) of the greasy condition that the track is generally in, and (2) of the bad alignment of track. The weight of the locomotive, instead of being only 7500 pounds, as stated, is really 11,500 pounds.

CYRUS ROBINSON, M. E.

Columbus, Ohio, May 7, 1894.

A Correction.

BY an inadvertence in the printing of this Magazine an engraving appears on page 404, as "Figure 10," the use of which was not intended, while the proper cut does not appear at all.

CURRENT TECHNICAL LITERATURE

TIDAL RIVERS. THEIR (1) HYDRAULICS, (2) IMPROVEMENT, (3) NAVIGATION. By W. H. Wheeler, M. Inst. C. E., author of "The Drainage of Fens and Low Lands by Gravitation and Steam-Power." (Longmans' Civil Engineering Series.) London and New York: Longmans, Green & Co. [Cloth. 8vo, viii+467 p. $5.]

THE old adage that "what is worth doing at all is worth doing well" has nowhere a greater significance than in the writing of technical reference-books, for it is an unfortunate fact that, when erroneous conclusions are drawn from special observations made by experimenters of recognized ability, the published results may be quoted as authentic for a century afterward. The science of hydraulic engineering covers such a vast field of experimental knowledge that every engineer is often obliged to accept on faith the published conclusions and results of the investigations of his predecessors. Where conclusions have been deduced without regard to the relative conditions, designs based on such conclusions may totally fail to produce anticipated results.

Mr. Wheeler's volume on tidal rivers will be a valuable addition to the library of any maritime engineer, yet in the above-named regard the work is no exception; in fact, if the whole of the chapter on "the transporting power of water" were expunged, the value of the work, as a book of reference, would be greatly enhanced. More than a century ago, Dubuat made a series of experiments with water flowing in shallow troughs to determine its transporting power at different velocities, and, although the results thus obtained have not the slightest bearing on what may occur in streams of greater depths, there is scarcely a reference-book on hydraulic engineering that does not quote Dubuat's values as authentic. To expect that any given velocity of flow, without regard to depth and volume of stream, will erode and transport particles or pebbles of a given size, is equivalent of assuming that an equation of two unknown quantities may be solved with one equation of condition.

The author also quotes Airy, Law, and Hopkins as authorities for the statement that the power of a stream to move bodies along the bottom varies as the sixth power of the velocity of flow. Since he admits that the energy of any stream to tear up particles adhering to the bottom only varies as the square of the velocity, it is hard to conceive how such power is suddenly increased to the sixth power of the velocity as soon as the particle commences to move, when the relative velocity is correspondingly decreased. It is true that the author of the book is not responsible for the errors of the works quoted, but, in quoting them without qualifying comment, he perpetuates the error and becomes equally subject to criticism.

The chapter on "tides" is a clear and concise discussion of the phenomenon in all its phases, from the development of the tidal wave in the Southern ocean to the ebb and flow in the various rivers and harbors of the world, and cannot fail to be of great interest to the reader who wishes to know what actually does occur, and does not care for the mathematical demonstration of the theory. The author could not resist the temptation, however, to do a little guess-work in some cases, where the cause of certain tidal phenomena was not entirely clear. And in undertaking to explain why there is but one tide each day in the Gulf of Mexico he says: "This may probably be due to the fact that the flood-tide, being driven into the gulf by the momentum of the ocean wave, and having a long run up the Mississippi and other large rivers which are connected with the gulf, pours so great a quantity of water into the gulf that the ebb has not time to get out again before it is met by the succeeding

flood, and consequently only every alternate wave reaches the head of the bay." Since the total ebb flow of all the gulf rivers for one tide is not sufficient to raise the gulf level $\frac{1}{10000}$ part of an inch, it is quite evident that the reason given is not tenable.

The chapters on the physical conditions of tidal rivers, the formation of bars at their mouths, and the principles to be observed in making improvements, show a careful study of the phenomena and generally correct conclusions as to best methods of amelioration. The physical characteristics of many American harbors, however, are so different from those of Europe that American hydraulic engineers will hardly be inclined to accept all the principles stated, as, for instance, "that a fresh-water stream is powerless to maintain a sea outlet and to keep down a bar."

Under the heads of "training," "dredging," and "examples of river improvement" a concise history is given of the methods employed, and the cost of the improvements that have been executed at the principal harbors of Europe. Full references are given to reports and papers relating to the various projects, so that the reader may readily look up the details of any particular enterprise in which he may be interested.

The style and general make-up of the book are good, and, although some of the views advanced will probably not meet the approval of experienced engineers, it will, no doubt, be read with great interest by all engineers interested in the development and improvement of tidal rivers.

GEORGE Y. WISNER.

Detroit, Mich., May 1, 1894.

ELEMENTARY METAL-WORK. A PRACTICAL MANUAL for Amateurs and for Use in Schools. By Charles Godfrey Leland. New York: Macmillan & Co. London: Whitaker & Co. [Cloth. 8vo. 111 p. $1.50.]

THERE is, at present, a revival in artistic metal-working, and iron-work is now regularly turned out from shops that rivals in beauty the productions of the most famous of medieval artists. It is needless to say that all malleable metals share with iron its possibilities for art purposes, except as preliminary to the remark that the book under notice, while dealing principally with iron as the most readily available material for the object of instruction in metal work, includes in its scope the treatment of all metals susceptible of being bent or wrought, cold or hot, by hammering, swaging, etc., into beautiful and decorative forms. One can scarcely conceive of a more delightful occupation wherewith to fill leisure hours than the kind of work herein described, which, in its lighter forms, is equally adapted to both sexes. But there is also an active commercial demand at remunerative prices for this kind of work, and those who possess cultivated artistic sense and excel in the execution of decorative metal-work readily find employment in it at good wages. The author is well known in America and Europe as the writer of many other treatises on art-work of various kinds, and was, until recently, director of industrial-art work in the public schools of Philadelphia. The most conspicuous feature of the work is its insistence upon the thorough mastery of elementary principles and manipulations, one after another, in due order, before attempts at even moderately elaborate work are essayed. In this the author accords with the views of the best educators in all branches of manual art; but in his book he adheres to this system much more strictly than is usual with instructors, who sometimes preach a doctrine they do not rigidly practise. The kinds of work upon which the treatise gives ample and systematic instruction are bent-iron or strip work; flat-sheet metal-work; molded sheet-metal work; repoussé or embossed-metal work; ornamental silver-work, and nail-, scale-, and stencil-work. The directions given for the execution of all these kinds of work begin with the most simple forms and progress by easy steps to more complicated designs. The text is exemplified by 124 well-executed illustrations and, on the whole, seems so complete a guide to the arts of which it treats as almost to take the place of a living teacher. A multitude of youths of both sexes would be much benefited by having this book placed in their possession, together with the needed imple-

ments and materials (all of which are described in it) for the cultivation of skill in this pleasant, and, to adepts, profitable art. Most potent influences in the early molding of character are interesting and innocent occupations exercising the constructive faculties, and the cultivation of taste for, and a love of, beautiful things. These, supplanting lower and baser influences, oppose what otherwise often leads to evil courses. The cover of Mr. Leland's book bears a tasteful design, emblematic of the art to which the work is devoted, which was evidently supplied by its accomplished author. LEICESTER ALLEN.

THE MECHANICS OF HOISTING-MACHINERY, INCLUDING Accumulators, Excavators, and Pile-Drivers. A Text-Book for Technical Schools and a Guide for Practical Engineers. By Dr. Julius Weisbach and Gustav Hermann. Authorized Translation from the Second German Edition, by Karl P. Dahlstrom, M. E., late Instructor in Mechanical Engineering at the Lehigh University. With 177 Illustrations. London and New York: Macmillan. [Cloth. 8vo. 329 p. $3.75.]

THIS volume comes like an old friend, although it has never appeared in English before. No author, perhaps, is more familiar to or more highly prized by engineers throughout the world than Weisbach. More engineers undoubtedly have been "brought up" on Weisbach than on any other authority, and his clear and simple notation and concise and incisive methods of analysis of the application of the principles of mechanics have become so well known as to be almost recognizable wherever found, even though they bear no other imprint of the author than that of his own individuality. Other portions of Weisbach's great work on engineering mechanics have found translators in Coxe, Dubois and Klein, treating respectively of theoretical mechanics, steam-engines and hydraulics, and machinery of transmission, and it has been through these translations that those who have not been able to study the subjects in the original have been able to become acquainted with the author. They have in fact become so popular and well known as text-books in our leading engineering schools that the volume before us needs no further introduction or higher commendation than the mere statement that it is another chapter in the series and that it maintains the same high standard of excellence. The book is divided into eight chapters devoted respectively to the following subjects: levers and jacks; tackle and differential blocks; windlasses, winches and lifts; hydraulic hoists; accumulators and pneumatic hoists; hoisting-machinery for mines; cranes and shears; excavators and dredges, and pile-drivers. The treatment is simple and direct and involves no mathematics higher than trigonometry. The illustrations are usually good and amply abundant. They seem also, where concrete examples are given, to be brought nearly down to date. This is particularly noticeable in windlasses, winches and lifts, mine-hoists, cranes and shears, and excavators and dredges. The book has an effective index.

MINING: AN ELEMENTARY TREATISE ON THE GETTING of Minerals. By Arnold Lupton, F. M., M. I. C. E., F. G. S. London and New York: Longmans, Green & Co. [Cloth. 8vo. xxiv-519 p., with 596 illustrations. $3.]

THE modest appellation "an elementary treatise," by no means gives a fair impression of the scope and character of this work. On the contrary, within the limitations necessarily involved in any attempt to cover the whole field of mining in a single volume, it is a very thorough-going and practical work; certainly no one book on mining comes nearer the mark, though there are numberless works treating special branches in more detail.

One of the first things that strikes the reader is the admirably simple, direct, clear style of the text. There are no words wasted; everything is to the point. For example, in the opening chapter, on geology —an inviting field for diffuseness and theorizing—the author presents as complete a review of known facts as need be desired by the practical miner who wishes to obtain a summary of general geology, as now understood by common consensus; though a little more information about ore deposits might be pertinent. The same remark holds good as to all succeeding chapters—which relate to exploration, boring, winning (or mode of approaching the mineral), sinking and sinking-machines, opening out, methods of working different substances, ventilation, chemistry of

mines, coal-dust (dangers and remedies), safety-lamps, blasting, power-drills and heading-machines, coal-cutting machinery, timbering, underground haulage, transmission of power, winding-engines, pit-frames and hoisting-apparatus, safeties, pumping-engines and pumps, treatment of mineral at surface, miners' tools, etc.

While the book touches upon all branches of mining, it is more particularly devoted to coal-mining, yet is not altogether unbalanced on that account.

It is an English book. That means of course that it contains much to which American engineers may—and justly, I think—take exception. Methods and appliances which are standard in English and continental practice certainly do not always answer in the United States. Yet as foreign engineers—and the distinguished author not less than any—are acquainted with American machines and methods, but persistently retain in many cases those which we here consider obsolete, they must at least be credited with doing so after full consideration of differences of conditions. It is precisely the same with mining as with railroading: where methods diverge it is safe to assume that those adopted in one country are best suited to it, while those followed in another are likewise proper. Else we would be forced to believe that the engineering talent and judgment of one nationality are inferior to those of another—which would lead to a senseless and ill-tempered wrangle over matters about which we agree to differ amicably, respecting each other's opinions and predilections and allowing for circumstances. When, for instance, we read detailed accounts of construction of circular brick- or masonry-lined shafts, of say 15 to 20 feet diameter, or of mine-tunnels built on the same plan, we are reminded of the rigid British locomotive (and the old controversy over it and the American pattern), yet neither, however unsuited to conditions here, is to be laughed at. English practice is slow and sure, solid and permanent; very conservative in adhering to precedents, so that advances are mostly made along well-defined lines by successive improvements. Here we are satisfied with lighter construction, look to more rapid returns for investment, and are more ready to devise and adopt new methods to fit special cases.

But if Mr. Lupton's book is British, it is not so in a bigoted or pedantic fashion. Indeed, the very fact that it is more especially devoted to European methods commends it to American readers. Those of us who have not had the advantage of inspecting foreign mines have to rely upon the books and the technical journals for information; and we want that information in just the precision here given, in order that we may not become narrow-minded and prejudiced in favor of local customs. For that matter, there is no real dispute as to essential principles—or else engineering would be a farce. It is in the details and means of reaching certain results that practice varies.

Perhaps the plainest compliment to be paid to "Mining" is to say that, while a reviewer is usually content to skim over a few pages here and there to get an idea of the merits of a book, and satisfies his conscience with this perfunctory survey, and while an engineer seldom reads through such books for the sake of reading them, but uses them in part for reference, in this case the reviewer confesses to having gone over every page (barring tables, etc.), because each commanded attention, before penning this notice. The author must excuse the naïveté of the compliment in view of its sincerity. A. W., JR.

PATENT-OFFICE MANUAL, INCLUDING THE LAW AND PRACTICE of Cases in the United States Patent Office and the Courts Holding a Revisory Relation Thereto. By George H. Knight. Boston: Little, Brown & Co. [Sheep. 8vo. 655 p. $5.]

THE author of this manual brings to his work the practical experience of more than half a century, during much of which time he has been a patent solicitor and an expert in his profession. Its object, after discussing the nature of the patent franchise, is to afford patent solicitors, lawyers engaged in patent practice, and inventors a compact handbook on the application for a patent and its preparation and prosecution. It embraces, in excellent arrangement, a sum-

mary of the more important decisions, up to date, relating to patents for inventions and designs and also to trade-marks and labels. These summaries are satisfactorily prepared, and are supplemented by copious references to cases which illustrate or which seem to qualify or form exceptions to general rules.

THE ELECTRIC TRANSFORMATION OF POWER AND ITS Application by the Electric Motor, Including Electric Railway Construction. By Philip Atkinson, A. M., Ph.D. New York: D. Van Nostrand & Co. London: Crosby, Lockwood & Son. [Cloth. 8vo, 233 p.]

THIS is another of the very many cheap attempts to supply so-called popular electrical literature merely for the sake of whatever profit there may be in issuing a book of late date. The author does not fall into as many errors as some other makers of such books, and this must be marked down to his credit, but the general character of the publication reminds one forcibly of those portions of the American electrical journals devoted to gratuitous trade notices of the electrical apparatus of their advertisers. It has more merit than they, but there is scarcely room for another such book and we are sorry to see this one.

A POCKET-BOOK OF ELECTRICAL ENGINEERING FORmulæ. By W. Geipel, M. I. E. E., and M. Hamilton Kilgour, Asso. I. E. E. and M. P. Soc. London: *The Electrician* Printing and Publishing Co., Limited. [Leather. 758 p., with index. 7*s.* 6*d.*]

THIS work is fully in keeping with the high standard usually maintained by the books issued from *The Electrician* press. It is the most ambitious attempt thus far made to produce an all-embracing pocket reference-book for electricians. At first sight it would appear that the title *electrical* engineering formulæ was an ill-chosen one, for we find within its covers much space devoted to formulæ and other matter not strictly electrical. For instance, we find such formulæ as those for the determination of sound in various media; for determining the strength of materials; the trigonometric functions; tables of radius in terms of degrees; hyperbolic sines and cosines; differential coefficients and general integrals; standard screw-threads for gas-, water-, steam-, and hydraulic-tubes; formulæ for heating buildings, etc. But we must remember that the electrician must be all things to all men; that there is now no branch of engineering in which he may not be called to have his say; in fact, until the profession becomes more specialized he must in fact be a "jack-of-all-trades." While such conditions obtain there is scarcely any source of information which he can afford to neglect. His pocket-book of formulæ can therefore never be too comprehensive until it becomes too large to be a pocket-book.

This book has been criticised because it has not been confined to purely electrical formulæ, but in view of the, present state of the science, who shall say what are and what are not formulæ that the electrical engineer may be called upon at any moment to use? We think the value of the book is enhanced rather than depreciated by this additional matter.

MODERN AMERICAN PISTOLS AND REVOLVERS. BY A. C. Gould (Ralph Greenwood). Illustrated. New Revised Edition. Boston: Bradlee Whidden. [Cloth. 8vo. 222 p. $1.50.]

THIS is a well-written book by a well-known authority on fire-arms. In it are described all the modern American pistols and revolvers, many of which are well illustrated. It includes also reports of tests of pistols and revolvers at all ranges, by the author and by the ordnance board of the government; sights used for the various kinds of shooting; ammunition for pistols and revolvers, and their merits; directions for making ammunition; records of the performances of pistols and revolvers; diagrams of famous scores; portraits of famous American shots and the rules followed by shooting-clubs, the United States army and navy, and the National Guard.

WHAT AN ENGINEER SHOULD KNOW ABOUT ELECTRICity. By Albert L. Clough, E. E. Illustrated. Boston: The Mason Regulator Co. [Paper. 12mo. 108 p. 50 cents]

THIS little brochure is a meritorious compilation of much useful electrical matter, including an authorized copy of the rules and requirements of the Underwriters' International Electric Association, for the installation of electric light and power. We have two criticisms to make, however. In the first place, the title is

entirely too broad. Secondly, we seriously object to one's signing after his name the initials "E. E." If the author has such a degree from any reputable institution authorized to grant the degree of Electrical Engineer he is entitled to use it, of course; but if he has not, he places himself, by using it, in the same category as the boxing-master or horse-trainer who dubs himself "Professor." None of our leading electricians use the initials at present; it is considered bad form to use them.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES. Published Monthly. Vol. XIII. No. 3; March, 1894. Philadelphia: John C. Trautwine, Jr., Secretary. [8vo. 30 cents, $3 per year.]

THIS well-known journal, in which are published the papers and proceedings of the eight engineering societies of Boston, Chicago, Cleveland, Kansas City, Minneapolis, Montana, St. Louis and St. Paul, and of the Wisconsin Polytechnic Society, has appeared in a new dress and presenting other novel and attractive features. Early in the present year Mr. John C. Trautwine, Jr., was made the secretary of the Association, and the publication office was removed to Philadelphia. Conspicuous among the innovations is the adoption of an enlarged type and an enlarged page. The editor has introduced, under the caption of "The Contribution Box," a department of notes and communications contributed chiefly by members of the several societies in the association, and one of book-notices. In addition, the *Journal* contains, as it has done for years, a valuable index to technical literature, prepared under the auspices of Professor J. B. Johnson, of Washington University, St. Louis.

The present number opens with a memoir of the late I. C. Chesbrough, whose portrait forms the frontispiece. Then follows a valuable discussion, held under the auspices of the Boston Society of Civil Engineers, upon the fruitful subject of the construction of reservoir embankments. In this discussion a number of our most prominent engineers describe their experience and state the views to which that experience has led them. A short paper by Mr. Arthur A. Skeels, of Cleveland, illustrates and describes a proposed new system of electric railroad signals.

NEW BOOKS OF THE MONTH.

Bancroft, Hubert Howe. = Resources and Development of Mexico. Published separately in English and Spanish. Illustrated. San Francisco and Chicago: The Bancroft Co. [Cloth. 8vo. $4.50.]

Brunor, Martin.=The Practical Electroplater. A comprehensive series on electroplating, with notes on ancient and modern gilding and formulæ for new solutions. Illustrated. New York: Emile Brunor. [Half leather. 12mo. $10.]

Birkmire, W. H.=Skeleton Construction in Buildings. New York: Wiley & Sons. [Cloth. 8vo. $3.]

Burn, R. Scott, *editor.*=The Steam-Engine User. Being practical descriptions and illustrations of the stationary engine in its various forms, with details of the boiler and furnace, their applications and fittings; of the engine with details of modern valve-gear, the multiple cylindered or compounded system of working, etc.; with descriptions and illustrations of heat prime movers other than the steam engine, by various writers. New York: Ward, Locke & Bowder, Limited. [Cloth. 8vo. 402 p. $2]

Cary, G. H.=How to Make and Use the Telephone. A practical treatise for amateurs with working drawings. Illustrated. Lynn, Mass.: Bubier Publishing Co. [Cloth. 16mo. 117 p. $1.]

Crandell, C. L.=Railway and Other Earthwork Tables. New York: Wiley & Sons. [Cloth. 8vo. $1.50.]

Crandell, C. L.=The Transition Curve. New York: Wiley & Sons. [Morocco. 12mo. $1.50.]

Fijnje Van Salverda, J. G. W.=Aërial Navigation. From the Dutch, by George E. Waring, Jr., with notes concerning some recent developments in the art. New York: Appleton. [Cloth. 12mo. 209 p. $1.25.]

Fiske, John.=Edward Livingston Youmans. A Sketch of his life, with selections from his published writings and extracts from his correspondence with Spencer, Huxley, Tyndall, and others. New York: Appleton. [Cloth. 8vo. 6-597 p. $2.]

Gorby, S. S. [State Geologist.]=Eighteenth Annual Report on the Geological and Natural Resources of Indiana, for 1893. With map of Quarries and Gas and Oil Fields. Indianapolis: W. B. Burford. [Cloth. 8vo. 356 p. No price.]

Haldane, J. W. C.=Steamships and Their Machinery; From First to Last. New York: Spon & Chamberlain. [Cloth. 12mo. $6.]

Henthorn, J. S., and Thurber C. D.=The Corliss Engine and Its Management. Edited by E. P. Watson. Third edition, with appendix by Emil Herter. New York: Spon & Chamberlain. [Cloth. 16mo. $1.]

Houston, Edwin J.—Outlines of Forestry; Or the elementary principles underlying the science of forestry. Philadelphia: Lippincott. [Cloth. 12mo. $1.]

Hughes, Norman. = The Manneto Hand Telephone. Its constitution, fitting up and general adaptability to every day use. Illustrated. New York: Spon & Chamberlain. [Cloth. 12mo. 80 p. $1.]

Huxley T. H.—Science and Christian Tradition. Essays. (Vol. V of Collected Essays.) New York: Appleton. [Cloth. 12mo. 34-419 p. $1.25.]

Ingersoll, Royal Rodney.—Text-Book of Ordnance and Gunnery. Compiled and arranged for the use of naval cadets, United States Naval Academy. Illustrated. Baltimore: The Author. [Half leather. 8vo. 264 p. $3, net.]

Johnson, J. B., Bryan, C. W., and Turneaure, T. E.=Theory and Practice in the Designing of Modern Frame Structures. New York: Wiley & Sons. [Cloth. 4to. $10.]

Johnson's Universal Cyclopedia. New and revised edition. Edited by C. Kendall Adams, assisted by Thirty-six editors of departments. Illustrated. In eight volumes. Vols. I-IV. New York: D. Appleton & Co. [Cloth. 8vo. $6 per volume.]

Kanschinger-Fürst, Herrman.—The Protection of Woodlands. Authorized treatise from the German of Kanschinger-Fürst's Waldschultz, by J. Nisbet. New York: W. R. Jenkins. [Cloth. 8vo. $3.50.]

Kelly, J. D. Jerrold.—Our Navy. Its Growth and Achievements. A History of the Navy of the United States from the beginning of our government. Illustrated by F. S. Cozzens. Hartford, Conn.: American Publishing Co. [Paper. 4to. $15. Edition de Luxe, $50.]

Kinney, Clesson S.=A Treatise on the Law of Irrigation. Giving all the case and statutory law in the United States. Washington: Lowdermilk. [Sheep. 8vo. $6.50, net.]

Langley, S. Pierpont.—The Internal Work of the Wind. Washington: Smithsonian Institution. [Paper. 8vo. 3-23 p. 25 cents.]

Leland, C. Godfrey.=Elementary Metalwork. A practical manual for amateurs and for use in schools. New York: Macmillan. [Cloth. 4to. 111 p. $1.50.]

Lick University Publications, Vol. II.=Double Star Observations from August, 1888, to June, 1892. By S. W. Burnham. Sacramento, Cal.: A. J. Johnston. [Cloth. 4to. 255 p. No price.]

Louis, H.=A Handbook of Gold-mining. Illustrated. New York: Macmillan. [Buckram. 8vo. 504 p. $3.25, net.]

Mauchline, Robert.—The Mine Foreman's Hand-book of Practical and Theoretical Information on the Opening, Ventilating of Collieries. Questions and Answers on practical and theoretical coal-mining. Designed to assist students and others in passing examinations for mine foremanship. New edition. Illustrated. Philadelphia: H. Carey Baird & Co. [Cloth. 8vo. 337 p. $3.75]

NEW TRADE CATALOGUES.

Any of these catalogues free on application to the manufacturers.

The Watts-Campbell Company, Newark, N. J.=Improved Corliss Steam Engines. 48 p. [Important information in steam engineering, etc.]

William A. Harris Steam Engine Company, Providence, R. I.=The Harris-Corliss Engine. 60 p. [Condensing engines, tandem compound engines, coupled engines, etc.]

Ames Iron Works, Oswego, N. Y.=High Speed Automatic Engines. 23 p. [Detailed specifications, tables, etc.]

Chandler & Taylor Co., Indianapolis, Ind.= Saw Mills. 32 p.

Chandler & Taylor Co., Indianapolis, Ind.= Engines and Boilers. 31 p.

Wm. M. Taylor Mantel and Grate Co., Chicago.=Fine Wood Mantels, Grates, and Tiles. 32 p.

The Hoppes Manufacturing Company, Springfield, Ohio.=Live Steam Feed Water Purifier and Exhaust Steam Feed-Water Heater. 58 p.

R. A. Crawford Manufacturing Company, Pittsburgh, Pa.=Patent Automatic Wheel Guard and Pick-Up Fenders for Cars. 24 p.

S. C. Johnson, Racine, Wis =Suggestions for Parquetry Floors. 16 p.

The Riker Electric Motor Company, Brooklyn, N. Y.=Electric Motors and Dynamos. 38 p.

The Interior Conduit and Insulation Company, New York.=Lundell Motors and Dynamos. 24 p. [Slow speed, direct current.]

Solar Carbon and Manufacturing Company, Pittsburgh, Pa.=Catalogue and Price List. 26 p. [Experimental carbons a specialty.]

The Iona Manufacturing Co., Boston.=Electric Specialties. 20 p. [Sockets, cut-outs, switches, etc.]

The J. M. Carpenter Tap and Die Company, Pawtucket, R. I.=Taps, Dies, Screw-Plates, etc. 32 p.

James V. Burke, Chicago, Ill.=Burke's Smokeless Furnace. 30 p.

The Gordon Hollow Blast Grate Company, Greenville, Mich.=Combination Draft and Blast Grate Bar. 14 p.

The Phœnix Automatic Filter Company, Racine, Wis.=A Practical Treatise on Oil-Filtration; Description of Filters. 40 p.

James A. Taylor & Co., Wilmington, Del.= American Standard Gage and Tool Works. 30 p. [After Richard's system, measuring instruments of precision; adjustable blade, shell, and rose chucking reamers.]

Eastern Electric Cable Company, Boston.= Wire Tables and Price List of the Clark Wire and Cables. 12 p.

The Buffalo Steam Pump Company, Buffalo, N. Y.=Steam Pumping Machinery. [64 p. [Useful information on steam and water pressure etc.]